WASTE PRODUCTS

AND

UNDEVELOPED SUBSTANCES:

A SYNOPSIS OF PROGRESS

MADE IN THEIR ECONOMIC UTILISATION DURING THE LAST QUARTER OF A CENTURY AT HOME AND ABROAD.

By P. L. SIMMONDS,

EDITOR OF 'THE JOURNAL OF APPLIED SCIENCE;'
HONORARY VICE-PRESIDENT OF THE ACADÉMIE NATIONALE, PARIS; HONORARY AND CORRESPONDING MEMBER OF THE SOCIETÉ INDUSTRIELLE, MULHOUSE, THE SOCIETY OF ARTS, LONDON, AND VARIOUS BRITISH, COLONIAL, AND FOREIGN SOCIETIES.

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PREFACE.

About eleven years ago I published a work under the same title as this book, which had a large circulation, and commanded more notice than its merits deserved, because it was hastily and badly arranged. Since that period the subject has acquired a much higher importance, and although waste objects are for the most part unsightly, yet the authorities of the Vienna International Exhibition this year thought it right to set apart a special Section, where each exhibiting country might show what it had done in this direction, since the first London International Exhibition. I formed, by request of the British Commission, a representative collection for Vienna, illustrating some of the leading industries and utilising processes which have sprung out of waste in this country.

Great Britain was the first to carry out this utilization on an extensive scale, and her example is now being followed largely on the Continent, in Australia, the United States, and even in the River Plate States, where numerous substances, formerly wasted, have now become profitable articles of commerce.

As my former book on Waste has long been out of print, —looking too at the increasing importance of the general subject—it appeared to me desirable to prepare a volume which should afford some information to experimenters and manufacturers, and with this view I have written an entirely new book. Having long given much attention to

the diffusion of practical information on the Utilization of Waste and Refuse, and the accessory products from manufactures, by various essays and lectures, which have been widely circulated on the Continent and in America, I have had the satisfaction to find that many of the hints and suggestions thus thrown out have led to the establishment of many great and profitable economic industries, and to the useful application of numerous formerly neglected natural products.*

I can claim little or no merit for originality in this work, for I am but a gatherer and disposer of other men's goods. In the course of long and extensive reading on this subject, I have been able, however, to accumulate much useful information, not generally accessible to the public, which I have endeavoured to classify and arrange systematically, simplifying reference by a full index.

P. L. SIMMONDS.

85, Finborough Road, West Brompton,
August, 1873.

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* The following, among others, are papers on this subject, which I have read before the members of the Society of Arts, Manufactures, and Commerce, London, at various times, and which are published in their Journal.—1. "On some Unappreciated and Unused Articles of Raw Produce from different parts of the World," read Nov. 29, 1854, (vol. iii. p. 33); for which the Society's Silver Medal was awarded me. 2. "On the Utilization of Waste Substances," read Feb. 9, 1859 (vol. vii. p. 175). 3. "On the Useful Application of Waste Products and Undeveloped Substances," read Feb. 3, 1869 (vol. xvii. p. 171).

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THE ARCHDUKE REGNIER, the President of the Imperial Commission of the Vienna International Exhibition for 1873, in a circular issued, inviting the display of Waste Materials and their products, makes some observations which deserve quoting:—"The consumption of soap and paper, the quantity of letters exchanged, the extension of public libraries, and the use made of them, &c., are often taken as a measure of the actual degree of civilization of a nation. An extensive and refined use made of the waste materials of industry and housekeeping might be considered with equal right as the measure of the degree of industrial development and capability. It would also scarcely be possible to find in the processes of Manufacture and in Agriculture an instance which shows to the same extent the really creative force of Science, and the characteristic tendency of a nation to economise, as well as its endeavour to keep, like nature, all within the circle of reproduction. Side by side with the increase and growth of wants, we see the quantity of useful material augment in a twofold manner. This is accomplished partly by making use of substances formerly useless, because their qualities were unknown; but still more by the use made of substances which, formerly considered as used up, appeared to be of no value, and were often incommodious and in many cases troublesome. In order to prove, only by a few actual cases, the assertion made, that the use of waste materials increases, and that thus difficulties are removed, and the wealth of the nation at the same time increases, it is only necessary to

take for an example the quantities of waste materials of soda factories, which were formerly a real nuisance. Nowadays, a great part of the sulphur contained in them is extracted, and the remainder, containing chalk and gypsum, is employed as valuable material for agriculture. The acid manganese solutions of chloride of lime factories have become restored to use by means of an ingenious chemical process. The scoriæ of metals produced by blast-furnaces is now used in glass-making, and becomes, by a simple physical process—called basalting—a substance useful in the construction of buildings and paving streets. Coal-tar and wood-tar play, in our time, an important part. It is sufficient to call to mind the beautiful aniline colours, without speaking of a host of substances which have become useful, like benzine, paraffin, creosote, carbolic acid, pyrocatechic acid, &c. Injurious and even poisonous gases which escape during the process of smelting (sulphuric acid, arsenic, zinc vapours, &c.) have not only been rendered innocuous by contrivances to condense and absorb them, but have also been usefully applied. Cotton seed, which was formerly utterly useless, acquired an increased importance from the moment when the means of making oil from it was discovered. So also with soap-lees from laundries, for we now know how to obtain fat-acids from them. Before the International Exhibition of London, in the year 1851, the glycerine in the process of stearic acid candle manufacture, and the ammonia from coal-gas, were lost altogether; since then they have both become important objects of commerce. Woollen rags, which were formerly only used for the production of Prussian blue and inferior paper, and for the most part were thrown on the waste-heap, have now become raw materials, as well as silk and cotton refuse, for re-use in textile industry, and thus render respectable clothing material accessible even to persons of very moderate means. The distillers' wash, produced in molasses distilleries, and which was formerly thrown away, has become just as useful for the reproduction of potash obtained from it, and now forms the base of many valuable alkaline salts; blood has become useful for the production of albumen; cork-cutters' refuse for the manufacture of floor-cloth; old horse-shoe nails and other scrap iron for the fabrication of the soft and malle-

able iron for English fowling-pieces; and so on with saw-dust and leather refuse, &c. How enlarged we find the quantity of useful materials, and the means of satisfying our requirements, in a retrospective view of the last ten or twenty years only! It suffices to single out, from the host of substances, the value of which has been thus increased, one much despised material, viz., human excrements. Without contradiction, these are considered as some of the most disgusting wastes; nevertheless, China and Japan mainly owe their flourishing agriculture to the extensive use made of them, and one of the greatest chemists of our time, Baron Liebig, has acknowledged that they contain the means of restoring to the soil of Europe its power of production, a power which will soon be exhausted otherwise. Considering this, is it not one of the greatest absurdities to spend millions in getting rid of a substance which would, if we made proper use of it, make us by several millions richer? Who can deny that the increasing use of wastes, the development thus made of new and abundant resources, and the facilitated removal of so much which annoyed us, proves beyond all doubt the great influence which Science exercises upon life, and obliges even a superficial observer to remark the gradual development of intelligence and prosperity. Who can deny that, when one observes the use made of waste materials, during a certain given space of time, a new picture of civilization unfolds itself?"

It is one of the most important duties of manufacturing industry to find useful applications for waste materials. Dirt has been happily defined as only "matter in a wrong place;" and the object of this work is to show the useful appliances of some of the most common objects. On this subject Dr. Lyon Playfair, in one of his lectures, says:—"Chemistry, like a prudent housewife, economises every scrap. The clippings of the travelling tinker are mixed with the parings of horses' hoofs from the smithy, or the cast-off woollen garments of the poorest inhabitants of a sister isle, and soon afterwards, in the form of dyes of brightest blue, grace the dress of courtly dames. The main ingredient of the ink with which I now write was possibly once part of the broken hoop of an old beer-barrel. The bones of dead animals yield the chief constituent of

lucifer-matches. The dregs of port-wine, carefully rejected by the port-wine drinker in decanting his favourite beverage, are taken by him in the morning as Seidlitz powders to remove the effects of his debauch. The offal of the streets, and the washings of coal-gas, reappear carefully preserved in the lady's smelling-bottle, or are used by her to flavour blancmanges for her friends. This economy of the chemistry of art is only in imitation of what we observe in the chemistry of nature. Animals live and die; their dead bodies, passing into putridity, escape into the atmosphere, whence plants again mould them into forms of organic life; and these plants, actually consisting of a past generation of ancestors, form our present food."

One of the greatest benefits that Science can confer on man is the rendering useful those substances which, being the refuse of manufactures, are either got rid of at a great expense, or, being allowed to decompose, produce disease and death. A large number of substances are now used in various ways which were formerly regarded as offal, and cast away; but a great number still invite the ingenuity of men of science to find for them useful applications.

It may be truly said that there is scarcely any manufacture in which there does not remain, in the form of residue or waste, something which, though not suited for that special manufacture, has still a considerable economic value. And this may generally be usefully employed in some way or other. This is one of the characteristic and salient points of modern enterprise, not only to allow nothing to be wasted, but to recover and utilise with profit the residues from former workings. The diminution in price which results from utilising matters otherwise wasted, may easily be conceived. In this respect extensive works and factories are in a better position than small ones, in consequence of the larger quantity of residues at their command, and which necessitate special machinery for working up or utilising. In great industrial centres, too, the waste products of a large number of works may be easily collected.

The utilisation of waste matters is a subject of much importance, to which too little attention is still paid by the inhabitants of many towns and cities. There is an immense variety of substances even now allowed to be wasted which are capable of being profitably converted to

use in the arts and manufactures. Modern science has pointed out the uses of many substances which were formerly regarded as offal, and thrown away; and the result is, that in England and on the Continent scarcely anything is entirely wasted. Refuse animal substances are particularly capable of being converted to useful purposes.

The thought of collecting and utilising waste is making extended progress even in the United States, where raw materials are more plentiful and the population is less dense and urgent in its economising requirements; the residues are there beginning to be systematically and extensively worked up. The 'Commercial Bulletin' of Boston states:—

"The collection and utilising of old material has become a very important business feature in all our large cities and manufacturing centres. But little need be lost. Scarcely a single staple article for use or ornament can be named that, having served its leading purpose, is not again put to service, either in a new and distinct form, or compounded with other matter. And this economising and working up the odds and ends, the refuse of our shops and homes, has assumed its present great importance only within the past fifteen years, and more especially during and since the war of the Rebellion.

"The collection, sorting, and distribution of old material have settled into a regular system. Mills and manufacturers have, of late years, turned attention to the production of specialities, and, as a consequence, are calling for particular and carefully-selected stocks. This policy has driven the dealers in 'old junk' into a regular routine for the sale and delivery of their stuff; and, while the market is constantly affected by supply and demand, the stock is all worked off into the hands of large dealers, who, in turn, re-sort and classify according to the specialities desired, and then stand ready to job off their grades and sorts in large amounts to the manufacturer. It is safe to say that at least seven-eighths of all the old material bought and sold in New England only reach the manufacturer through the hands of about eight different dealers in this city. There was a time when the tin-peddler, roughly sorting his stock, sold it direct to the mill, when the petty junk-dealer took his little bag of stuff and weighed it out to the manufacturer; but we have changed

that. The peddler's waggon and hand-cart leave their odd lots with the old junk stores; there it is carefully sorted, and is carted to the middle men; they sort it into immediate market grades, and sell to the larger dealers who have a specialty; they, in turn, sort and classify to meet the wants of consumers; so that old material is as shrewdly dealt in as any other class of merchandise. While it admits of no classification other than as it is quoted, there still will exist under careful manipulations minor grades in each class that will enhance the value from one-eighth of a cent to two cents per pound for straight lots. It would be almost impossible thoroughly to describe the immediate and, to a stranger in the business, delicate differences to be found running through the whole market of old materials, or to explain satisfactorily the use each quality has.

"Of the several kinds of junk, a large percentage of the paper stock of the South is accumulated at the seaports and shipped to Boston. The chief point of collection is New Orleans, whence comes to one firm in this city over three hundred thousand dollars' worth per month. The West bids fair to enter at New Orleans in sharp competition with New England in the purchase of old material. There are many things now that the West does not call for, and which are collected and sold to our dealers here as a sort of legitimate appendage to desirable stocks. Broken glass that contains lead, such as tumblers, decanters, &c.; old bones, scrap hides, refuse cotton, &c., that have in the South little market value, but which, when shipped North on an invoice that covers a good assortment of more valuable material, realise clever profits. This is the reason for still sending the bulk of the best selections to New England, notwithstanding the cost of transportation is more than to the Ohio or Upper Mississippi. But the time is likely near at hand when the South herself will consume the bulk of the old materials. Yankee capital and thrift are invading that soil, and planning and planting factories at all available points. Nearly all of our leading Boston dealers have large investments in this section, and are fully alive to the coming wants of manufacturers. It may not be improper to state that a thorough system of collecting, sorting, and shipping these stocks has been going

on throughout the South since the Rebellion, controlled chiefly by Boston men; and, as the demand for use there occurs, the needed supply is meted out in a manner bespeaking at once a New England method.

"In the New England States, over fifteen million dollars' (3,000,000*l.* sterling) worth of old material is annually worked over; and at least five hundred thousand dollars' worth of this peculiar stock could at any time be thrown upon the market by the Boston dealers. The amounts consumed by our mills are astonishing, especially of shoddy. Woollen mills could be named that purchase each year from three to six thousand dollars' worth of shoddy, and this, too, in addition to flocks. Very many paper-mills have standing orders with the largest paper-dealers for thirty and fifty tons of stock per week. The Kingsley Iron and Machine Company receive and consume from sixty to seventy-five tons of scrap-iron each week, and the Old Colony and Ames Shovel Companies stand ready to take all the old wrought-iron offered in the market. Nearly all the old lead sold in this vicinity is purchased by the Boston Lead Company, and one dealer, who makes it a specialty to supply them, turns in, on an average, one hundred tons per month."

I am aware that there is a kind of contradiction of terms in the expression of the utilisation of waste, since, by the utilisation of all residuary matters, there will be no waste in any manufacturing operations. There are many natural products, however, yet lying waste or undeveloped, to which attention will one day be prominently turned, as new demands arise to be supplied. My desire is to press upon the attention of all persons engaged in the useful arts the importance of the prevention of waste, and I shall advert briefly to the utilisation of the refuse products of certain manufactures and processes of domestic economy, with the hope of suggesting to those engaged in other trades the profits which might accrue to themselves, and the benefits which would result to mankind, from the useful application of these hitherto worthless residues.

In our great textile industries all the residue and nominal waste is pretty generally utilised; the waste from the cotton, flax, jute, woollen, and silk manufactures is now fully appreciated and re-worked. Thus we import

some 35,000 to 36,000 cwts. of silk waste to be used up. There are at least 60,000 tons of cotton waste in the cotton manufacture, which, added to 20,000 tons of linen waste, and the same quantity from rope and canvas, gives a large total to be worked up again for various purposes.

Improvements in technical chemistry have added largely to the number and value of its products. This branch is susceptible of almost unlimited extension and application, in the creation of commercial and useful articles from the refuse of every other manufacture, and the diversified products, vegetable, animal, and mineral, of our own and other lands. Many of the chemical branches, apart from the money-value of their manufactures, are of the highest economical importance to the country, as auxiliaries to almost every other industry of the people. Chemistry has, as yet, revealed but a tithe of the vast wealth of its resources.

Faraday discovered, in the cylinders in which illuminating gas was formerly transported, a dirty, oily liquid, to which, subsequently, was given the name of benzole. Here was an instance where the utilitarian inquiry might have been made with great propriety: "What is the use?" Few discoveries have been more fruitful in their consequences than that of the detection of benzole among oil residues. Out of this body has sprung a long line of important industries — we have the most magnificent colours; we prepare sweet perfumes; we concentrate the light of illuminating gas; we dissolve resins and make varnish; and the investigations into the properties of this substance have conducted to the discovery of analogous compounds reaching far into the domain of organic chemistry.

The infinite variety of metamorphoses of which the tarry products are capable exceeds anything that the old necromancers could have painted in their most exuberant fancy. To be able to make exquisite colours and sweet-scented perfumes from anything so repulsive as pitch and tar has been pronounced a great proof of scientific progress; but the modern chemist has gone further, and increased our wonder by putting together in combination many of the same substances. Aniline colours are obtained from coal and carbon. It would be impossible to

give the infinite variety of shades and variations which different manufacturers can obtain from aniline. A taste for colours, and a growing demand for varieties, has led chemists to try to imitate some of the oldest and best-known dyes. Indigo and madder for a long time defied imitation; but now we have absolute reproductions of those colours, and the chemical process involved in the imitation is likely to affect the trade in these vegetable dyes. The annual consumption of madder is about 47,500 tons, worth more than 2,000,000*l.* The principle extracted from this dye root is alizarine; and artificial alizarine is now produced from anthracene, one of the coal-tar products. Thousands of acres of land in Alsatia, now devoted to the culture of madder, may on account thereof be restored to agriculture. It is thus that a simple experiment in a laboratory can affect the destiny of whole provinces, and divert into new channels capital long invested in important enterprises.

Margraf found that an unsightly weed, growing wild on the shores of the Mediterranean, contained a small quantity of sugar and a large proportion of soda. By transplanting and careful culture a large part of the soda was eliminated, and potash substituted in its place, and the quantity of sugar considerably increased. The weed was transformed into the sugar-beet and an industry established which has proved to be of great value to the European countries where beet-root sugar is made. In the tubers of another weed, the fruit of which, in the form of bolls, is highly poisonous, was found large quantities of starch. This also was subjected to culture, and at the present time few articles of food are of more consequence than the potato. The detection of sugar and starch in vegetables was not regarded as of much account at the time it was made, and it was many years before any practical results grew out of it.

Civilized man, having discovered that "nothing is lost in nature," has been busy in devising fresh fields for the application of what had hitherto been abandoned as having served its purpose, and therefore been rendered worthless. The uncultivated mind cast aside as unprofitable all residue after the original material had answered one specific object. It remained for a more advanced intelligence to make any

one raw product subserve to more than one interest. The savage having sucked milk from the cocoanut, had no idea of making its fibrous coating into a textile fabric; and the man who first turned rags into writing-paper must have been a great improvement on the aboriginal ape, which some would wish us to believe was his immediate progenitor. Our aim is now to utilise all things to the utmost possible extent. The uses to which they are turned are not always stale, flat, or unprofitable. We now produce valuable articles from what a few years ago was thrown away as a nuisance. Once the raw material gets into the clutches of the manufacturer, it is tortured by a score of processes to yield up all its virtues. This system extends throughout all our modern actions in domestic and rural economy, and in our commercial undertakings. Dirty salt, when not fit for the table, and salt from the fisheries, is made to fertilise the farm. The foul water and soap-suds of our day's washing are converted again to grease and soap, or turned to account in the garden. The abominations of our town sewers are converted into bread and beef, into milk and mutton. We grow linseed and make the straw into flax, extract oil from the seed, and then give the husk to our cattle in the form of cake, to produce Christmas beef. The animal's flesh thus fed is used as food, and the bones around which it hung are ground to powder to make the grass grow. Nothing comes amiss to our ingenuity. We consume our smoke, write and print on the remnants of our ragged shirts, and triumph over decomposition and stenches. Utilisation is the great law of Nature, and we are only following her teaching. The air we inspire gives us life, the poison we expire gives life to plants. She, true to herself, is never at a loss what to do with any of her elements. Man, in an artificial state of society, and in an enlightened age, also provides for converting all the material he uses into useful purposes. There must be no loss of anything once within his grasp. So much lost is so much power running to waste—it is the leak in the gas-pipe, the hole in the water-butt. But though almost all raw products are ramified into a number of new industries, and diverted to a variety of ends, it is needless to remark that our attempts in this way must, under existing circumstances, be greatly guided by their success as articles of

commerce. Philosophically, nothing should be lost. Commercially, much may be thrown away. If worn-out shirts could not be made into bran new paper at a profit, we should not at the present moment be checquering it with ink. So long as bones are a substitute for lime in agriculture, and it is cheaper to dissolve or grind them than to quarry limestone, crush it, and carry it to the land, so long only will they be thus used. There is no other argument but the commercial one that will keep shin-bones from the dust-bin and ash-heap. Soap-suds and dirty water will never grow Brussel sprouts, if soap-suds and dirty water can be more profitably applied. Dirt, which is cheap enough, is utilised as long as it gives us a clear profit. Guano may be the most fertilising agent ever known; but guano may be too dear, and will then lack purchasers. Manure, having all possible virtues, will not pay for its carriage if the distance be great, or the available power of transit be too expensive. Where the manufacture of butter pays better than the making of cheese, we must expect a difficulty in getting a Welsh rarebit. Philanthropic views, though often impracticable, are, doubtless, morally serviceable. But philanthropy has little chance of existence where it cannot afford to keep up an establishment. We appear, at least, not to have advanced beyond a paying philanthropy, and an utilisation which invariably ends in £. *s. d.* It is fortunate, to say the least, that, in many instances, what pays is for the general good. The converse may be equally as probable; but we should certainly hesitate before we entered on any speculation undertaken solely on the latter consideration. In Germany many large factories find remunerative labour by making golden syrup out of sulphuric acid and starch; and some ingenious Americans, we have recently been told, make currant-jelly out of old boots. This, no doubt, with much benefit to the manufacturer's pocket, but with great injury to the public stomach. On the other hand, selling cream at the price of milk, although it may benefit the poor of London, would only ruin the dairyman, whose benevolence in so doing could not possibly be doubted. "Will it pay?" then is, after all, the question usually put when any attempt is made to introduce a new product, or to utilise in a new way any of the residue material used in our popular in-

dustries. The introduction of sugar-beet into this country will be important, if the farmer can sell these roots to make sugar, and feed his cattle rapidly with the remaining pulp. Sugar-beet is at least, in one sense, a valuable importation; for although, perhaps, it is not yet thoroughly acclimatised, there is little doubt that it is capable of being successfully grown in this country. But whether at the present time it can be recommended to the farmer for its double use, in the way it is so persistently forced upon him in many quarters, is matter for careful consideration. The farmer will gladly admit the usefulness of such an accommodating plant, if it can be proved to be also a profitable one.

City Disinfection.—The value of the sweepings and waste products collected in cities is considerable, and frequently the right of collection is rented for a large annual sum.

In the City area of London (not the entire metropolis), forty waggons are constantly employed in carting away the dust and sweepings of the streets. In 1872 55,000 loads of mud and other refuse were removed from the footpaths and roadways in the City. The scavenging of the docks, the periodical rubbish sales there, the sweepings of the Corn-Exchange, and the collection of much other waste and refuse proves highly remunerative.

The enormous amount of mineral matter which, in the shape of bread and muscle, is collected from over a vast acreage of ground, and finds its greatest consumption in centres of population distant from the points of production is, in a great measure, lost to the soil. Man and his adjuncts among the animal kingdom have, it is true, liberated it in the production of muscular or brain force, but the waste products are mainly lost to agriculture, being swept, in the form of sewage, down the rivers into the sea. It is estimated that the annual loss to the soil, through this waste of solid and liquid excreta, is not less than ten millions of pounds to each one million of persons, and, of this amount, probably not less than 15 per cent. is phosphorus.

The excreta of man and animals contain all the mineral matters formerly contained in their food. It is, therefore, obvious and most natural, yet more an absolute necessity,

to return these excreta to the soil. Fresh fæces contain an average of 25 per cent. of solid matter and 75 per cent. of water. The mineral matters consist of one-third of phosphoric acid. Dried fæces are, of course, much richer on account of having lost the water. A city of 100,000 inhabitants would yield per year 1300 tons of dried fæces, containing 112,000 lbs. of phosphoric acid.

Professor Liebig says: "The coming generation will consider those men as the greatest benefactors of mankind who devote all their efforts to utilise and save the night-soil of the cities." Poudrette works have been established in the United States, Germany, France, and England; but none have ever yet united the sanitary with the agricultural interests. Some trials have been made to employ iron salts for disinfecting the night-soil, but such a poudrette is almost valueless. Other trials were made with lime, which only caused the loss of the ammonia, and had no disinfecting value whatever. Dr. Julius E. Dotch, of Washington, D.C., has patented a method for such disinfection, which appears to be of value. It consists in the application of a prepared earth, containing clay, sulphuric acid, and nitric acid, which is spread in thin layers over the fresh fæces.

By this means, not only is the formation of fungoid growth effectually prevented, but also all the ammonia is taken up on account of the sulphuric acid; and the sulphuretted hydrogen developed from the fæces will be entirely destroyed by the nitric acid present in the patent earth.

The Carbon Fertiliser Company, working on Mr. Stanford's patent, treats the refuse with sea-weed charcoal. In the 'Manufacturer' of New York it is stated that the United States deliberately throw away and totally lose yearly a sum sufficient to nearly pay half the amount of interest on the national debt. And this without object, without thought, and with no return, but by means of its sewers.

Victor Hugo, in 'Les Miserables,' touching on this important question of the utilisation of sewage, remarks:—"Science, after long experiment, now knows that the most fertilising and the most effective of manures is that of man. The Chinese, we must say to our shame, knew it

before us. No Chinese peasant, Eckeberg tells us, goes to the city without carrying back, at the two ends of his bamboo, two buckets full of what we call filth. Thanks to human fertilisation, the earth in China is still as young as in the days of Abraham. Chinese wheat yields a hundred and twenty fold. To employ the city to enrich the plain would be a sure success. *If our gold is filth, on the other hand, our filth is gold.* What is done with this filth, gold? It is swept into the abyss."

Mr. Leppmann, director of the central experimental station in Bavaria, speaks of the loss of fertilisers in the wastes of the city of Munich, which he estimates as containing a population of 177,000. The amount of available nitrogen annually lost in the human excrements, fluid and solid, of that city, he places at 1,857,714 lbs.; to which he gives a value of about 100,000*l.* While this waste is being suffered, the German fields are enriched by an annual importation of 1,000,000 cwt. of Peruvian guano, at a cost of about 600,000*l.* Munich, however, is but one of a number of German cities whose wastes, if calculated at the same ratio, would be equal in value to the fertilisers imported. Mr. Leppmann proposes that this waste be saved.

The Corporation of Antwerp, which used to pay 1000*l.* a year to get rid of the refuse of their city, now receives 40,000*l.* annually for the sweepings of the streets and the contents of the cesspools, contractors converting these waste substances into powerful guano.

Mr. J. Wiggin, F.C.S., of Ipswich, in reading a paper on 'The Sewage Question,' before the Framlingham Farmers' Club, made some remarks which deserve to be quoted:—"In times within the memory of some of us a state of things prevailed far more satisfactory in an agricultural point of view than the present one. The fæcal matter, ashes, and general refuse of the kitchen-midden were collected in dry receptacles, and periodically carried away by the neighbouring farmers' waggons. The matters so collected were really of value, as well as easily removed. Then the waste and rain waters ran down the streets in gutters, and were thus conveyed into the nearest river, the waste becoming oxidised by full exposure to the air, and so rendered comparatively innocuous. Thus the water

and fæcal matter were carefully kept separate; but nowadays all this, which I must call a natural arrangement, is entirely changed. The boasted civilisation of the present age has caused the difficulty by introducing the water-closet system, which, by mixing two substances valuable when separate, makes that worthless puddle now rapidly contaminating our water supplies and changing our pellucid rivers into offensive dirty streams. The earth-closet system of the Rev. Mr. Moule, and the sea-weed carbon process, introduced by Mr. Stanford, of the British Sea-Weed Company, are steps in the right direction, but up to the present time, all the proposals to deal chemically with the enormous dilution called town sewage have been failures; nor, from the very composition of the material, is it possible in its present form to do so. In order to do it economically, we must revert to old forms. It is true there are many companies formed, and plans in action, proposing various remedial measures, but none of them, I feel sure, doing it in the sense I regard the question. It may be they deodorise, and partially precipitate the carbonaceous matter and phosphates, but it is certain the ammonia and other nitrogenous forms of animal secretions, which, of themselves, constitute almost the only money value, go away in what is termed the effluent water, and are a dead loss to the community, whilst the manures they manufacture are comparatively worthless, from the great weight of lime and clayey matter used as precipitants; so that it is much cheaper for the farmer to buy his phosphates and ammoniacal salts as manufactured artificially. Much prominence has lately been given to the process of General Scott. This consists in precipitating the sewage, by adding a large quantity of lime, and forming Portland cement, by burning the mixture at a high temperature. This process is about to be adopted at Birmingham and East Ham. In fact, it is forced upon them by the impossibility of getting rid of the effluent water of the other processes. I consider this plan a wasteful as well as costly one. The total waste of ammonia in the manufacture, and the probable difficulty of sale of the cement, when a large quantity is daily made in every large town, must, I think, be against it. The medical question of the effect upon the health of those who reside near the kilns, and upon

others who live in rooms cemented with the compound, has yet to be ascertained. It may be that it will be found deliquescent, and to evolve gases injurious to health; at all events it is of no use to the farmer.

"The system of the Rev. Mr. Moule, that of receiving the fæcal matter on dry earth, is founded on correct principles, and will be, when modified, of great value to the agriculturist. Dr. Voelcker has published an analysis of this manure, his estimate of its value is much less than that of the inventor. He found that after two or three dryings it contained only 6·2½ worth of ammonia and the phosphates per ton.

"The last, and, probably, the best system, is that of Mr. Stanford. His is a dry one, but has this great advantage, that the sea-weed char used is also a disinfectant and deodoriser. From this reason the deposits do not need frequent removal. The charcoal may be used over and over again, till saturated, when it may be applied at once to the land, or be distilled for the ammonia, and then used in lieu of fresh. The economical advantages of Mr. Stanford's system are great; no expensive sewers and drains require to be made, it can be accommodated to every house, and be used in all-sized towns and villages.

"From what I have said, I trust that it will be evident that no system of town-sewage yet in practice furnishes products of any value. The best that can be said of them is, that they make a good basis, to which ammonia, the nitrates and phosphates obtained from cheaper sources, may be added. There can be no doubt the really valuable constituents of sewage are in solution, not suspension, and at present are all lost to the community. It is much to be regretted so enormous a waste should be going on. The value of fertilising matter imported into this country is yearly increasing. The national money loss is incalculable, besides which, if refuse matters were properly collected, a far greater amount of animal and vegetable food would be raised, and a great part of the corn and cattle imported as a necessity now would not be required. I trust before long some combined plan of the chemist and engineer may surmount this difficulty created by modern fashion. When the good time comes we shall have no necessity, as at present, to scour the world for fresh sources of guanos and

phosphates to renovate our exhausted soils; but, with the assistance of the atmosphere, keep up that admirable balance of fertilising power bestowed upon the land by the Creator in the beginning."

The municipal council of Paris adjudicated in 1872 to an English company the farming of the night-soil of that city. The superseded company paid the municipality half a million of francs yearly for the exclusive right to deal with the fæcal matters of the city; the new company pays three millions, and gives security to the amount of 500,000 francs to execute its contract. It is calculated that the new company will divide a net profit of a million of francs, by the adoption of more economic and efficacious processes, and the Corporation will complete the necessary sewage required. Seven contracts were sent in, the base of all being so much for a cubic yard of the sewage; the lowest offer was 14 sous (7*d.*), the highest 6 francs (5*s.*) The old company paid 17 sous, and in their renewed tender offered to pay double that sum. Recent analyses have shown that a cubic yard of the sewage yields 9 lbs. of nitrogen. In the closet system of Paris, except in the case of some new houses, water is not employed, the contents of the *cabinets* are directed into a common reservoir, which is pumped once a year into mounted cisterns and removed.

The water from the scullery is never permitted to flow into the reservoir, but is led directly into the street, and finds its way, by the kennel, into the grand sewers, into which some water-closets also empty themselves. This sewage has yet to be economised. It is to Bondy where the contents of the house reservoirs, or the hermetically closed cylinders and barrels, are conveyed, mixed with charcoal or peat, dried and reduced to powder, the resulting fertilizing compound, named *poudrette*, readily sells for 2 francs per bushel; converted into sulphate of ammonia, the compound, with 21 per cent. of nitrogen guaranteed, is sold at the rate of 30 francs per cwt.; it is delivered in a liquid state at 1 to 2 francs per cubic yard, according to the distance. The importance of liquid manuring and irrigation is every day making progress in France. In the Valley of the Moselle, the soil is not only irrigated as in Lombardy, but flooded occasionally; the river water depositing a small Nile-layer of rich sediment.

In the Valley of the Dives, in Calvados, the farmers erected dykes to keep their rich meadows from being flooded; the result was such a deterioration in their lands that the dykes have recently been levelled.

The 'Saturday Review,' in noticing the first edition of my book, in a pleasant article under the title of "The Reclamation of Waste," well observed that "the things denoted by words sometimes undergo a change for the better. They are divested of noxious and disagreeable qualities, and become useful members of society, and they are spoken of with different feelings accordingly. If they continue to bear their old names, these naturally cease to be hard names. This takes place in cases such as the gradual reclamation of waste substances, the purification of offensive and unwholesome matter, the discovery of uses for hitherto neglected and worthless articles, and the actual improvement of the world and its inhabitants in the progress of civilisation. In like manner, if all matter could be put in its right place, or to its right use, a variety of terms for waste and dirt would either disappear from our common vocabulary altogether, or change their signification. There would be no such things as weeds, rubbish, litter, refuse, offal, and dregs, in their present sense; and these words would either become obsolete, or get blended with different associations. Commerce and the useful arts have already accomplished changes of this sort to a considerable extent. Coal, for instance, was long in great disgrace as the name of a dirty and unwholesome fuel, unfit for household use—which, in fact, it was, while it filled the room with smoke and gas for want of proper means of ventilation. Until rags had obtained a high commercial value, and so long as they were only associated with repulsive forms of human misery, their name, like themselves, could have no other than a mean position, out of which increasing cleanliness and utility have been steadily raising it. So, among the things of which paper can be made, Mr. Simmonds enumerates sugar-cane trash, silk, flax, and cotton waste, woollen refuse, beetroot refuse, shavings, scraps of leather, cabbage stalks, thistles, and nettles; all of which are applicable to several other uses, and, being no longer outlaws, vagabonds, and nuisances in the world, may become citizenised in the language."

To those who have not carefully considered the subjeet, nothing is more wonderful than the number and variety of stages through which most materials pass on their way to utter worthlessness and complete dissipation, so far as the arts are concerned. The worn-out tin kettles and coal-scuttles that are beyond the reach of the tinker's art are collected together, the best portions are clipped out, cut into pieces of suitable size, punched with small holes, varnished with a cheap black varnish, and used by the trunk-maker to proteet the edges and corners of cheap trunks; and, even when no longer available for any mechanical purpose, they are of use to the chemist, who combines them with other substances and forms salts that are of the utmost value to the dyer and the ink-maker. Tho cast-off garments of the better classes find their way, through the agency of servant-girls and wardrobe collectors, into the hands of dealers who revamp them by removing stains and mending the worn-out parts. These renovated articles of dress then pass through a second stage, and perhaps enable some impecunious dandy to shine at balls and parties. When he can no longer wear them without offending his self-esteem, they pass to a still lower grade of wearers, and finally reach the rag-picker's basket and the junk-shop. But even then their course is not finished. The linen and cotton that enter into their composition pass into the hands of the paper-maker; and rags, at which even a beggar would turn up his nose, find their way into the boudoirs of the upper classes, and receive the amatory tenderness of those who fancy that they have nothing in common with the "great unwashed," The woollen goods, on the other hand, pass to the manufacturers of shoddy, who tear them to pieces, use the fibrous parts for tho manufacture of cheap and worthless goods, and send tho dust to the manure-dealers. And thus these several parts go their appointed rounds many times before they aro entiroly worn out—a thing which cannot be said of them until they have been roturned to the soil as manuro or to the air as fuel; in whieh cases thoy become food for plants, and take up a new cycle of existence.

But it is not only the utilisation of matcrials that have been worn-out in servico that claims our attention: the

value and importance of what may be called refuse matter is equally striking. The skins used by the goldbeater, or that enclose sausages, are produced from the offal of animals. The beautiful yellow crystals that we sometimes see in druggists' windows are made from the horny refuse of the butcher's shambles and knacker's yard. Every atom of the carcass of a horse is applied to some useful purpose. But the variety of purposes to which the different parts of common horns are applicable, and the care that is taken in well-regulated factories that nothing shall be lost, renders this branch of business even still more striking. The tanner who has purchased the hides separates the horns, and sells them to the makers of combs and the thin transparent shells that are still employed for some purposes. The horn itself consists of two parts—an outward horny case, and an interior conical-shaped substance somewhat intermediate between indurated hair and bone. The first process consists in separating these two parts by means of a blow against a block of wood. The horny exterior is then cut into three portions by means of a proper saw. The lowest of these three parts—that next the root of the horn—after undergoing several processes, by which it is rendered flat, is made into combs. The middle of the horn, after being flattened by heat, and its transparency improved by oil, is split into thin layers, which used to be employed for lanterns, and are still used for certain purposes in the arts. The tip of the horn is used by the makers of knife-handles and of the tops of whips, &c. The interior, or core of the horn, is boiled down in water. A large quantity of fat rises to the surface, which is collected and sold to the soap-makers; while the liquid itself, being in fact a weak solution of glue is sold for sizing and for stiffening cloth. The bony substance that remains after all the fat and gelatine have been saved is sent to the mill, ground down, and sold to the farmers for manure. These are well-known cases, and the lessons that they teach are obvious. We see the almost indestructibility of certain kinds of raw material, and we also learn the value of what at first sight appears to be worthless matter. These lessons are valuable, provided they do not lead us into the belief that waste material is of value under all conditions; for it is a curious fact, that it is only when

aggregated in large quantities that such matters possess any marketable value at all. If the producer were also the consumer, these materials would possess the same value whether they were collected in large or in small quantities; but, whenever it becomes necessary to find a market for them, they must be handled in large quantities or no profitable disposition can be made of them. There may be exceptions to this in a few instances, as in the case of paper-stock, for which there is an organised system of collecting which ascends from rag-pickers to junk-shops, and finally to paper-mills. The same thing is true in regard to iron, the smallest scrap of which is marketable. But in the case of horn tips, waste leather, or any similar material or product for which there is not a universal demand and consequently a wide market, a small quantity is unmarketable, and therefore worthless. From the fact that this peculiarity of certain otherwise valuable substances has been overlooked, the grossest fallacies have frequently entered into the calculations of inventors who propose to pay the expenses of some new process by the sale of the by-products. In no direction has this error taken deeper root than in that of inventions connected with the Voltaic battery. When Callan's battery was brought before the public, the expense of running it was to be defrayed by the sale of certain valuable chemical salts that were produced during its action; and, if we had believed all the statements made in favour of Bain's system of batteries and telegraphs, every man would have had a telegraph and battery in his house, and made money by the sale of the valuable pigments that were to have been produced. That these statements had a basis, in the chemical facts of the case, is true. Take even the commonest salt, sulphate of zinc, and, if we could get regular market price for what we produce, we could probably pay for the running of our batteries. But, when we take into account the expense of collecting and marketing small quantities of this substance, we shall find that it is cheaper to throw the worn-out liquids away than to spend time and trouble over them. So, too, in regard to pigments. A 100 lb. keg of red-lead would readily find a purchaser; but 5 lbs. of some new paint, though it were equally as good, might be hawked all over a city

without meeting a buyer. And yet, in every calculation in regard to the use of electricity as a motive power, the most extravagant estimates are made in regard to the returns that may be derived from the waste products.

A review of the whole matter, then, leads us to the conclusion, that, while no man can with safety neglect the waste materials and by-products of his establishment, on the other hand no man can afford to spend time and money in the effort to find a market for these, unless they are produced in large quantity and are well known in commerce. And before making a final estimate in regard to the probable amount that is to be derived from this source, we must first take into account the effect which is likely to take place from the throwing of such a large quantity on the market. Thus, for example, in the case of the sulphate of zinc just mentioned; it brings a certain price at the present time, but suppose that all over the country electro-magnetic engines were to produce it at the same rate that ashes are now produced by steam-engines—10,000 tons a day and more—how long would the price keep up? Sulphate of zinc would then fall in value until it brought the same price as any other ore of zinc and sulphur that could be worked with the same ease, and our finely-built air-castles would vanish like the fabric of a vision.

'The Times,' a few years ago, gave a curious article on "Old Clothes, and what becomes of them":—

"When the hawker working the suburban districts comes by with his barrow blooming with flowers and petitioning for old clothes, old hats, and old boots, &c., in exchange for them, the bargain seems so one-sided that most people are only too glad to begin the barter. We all get so sick of frowsy old clothes that it seems almost a mercy to get rid of them at any price, but to be able to translate them into geraniums and fuchsias, &c., to exchange musty, fusty gaberdines for fresh odours and rainbow hues, is more than anybody ever expected to do. The coster who initiated this subtle method of weeding our wardrobes must have had a special insight into female character, ever ready to exchange the solid and useful for the brightly decorative—at all events, this almost poetical method of filling old clothes' bags deserves to be mentioned as one of the most

abundant means of building up a trade which has now assumed enormous proportions. The great dealers into whose hands our cast-off skins ultimately fall have arrived at the dignified position of merchants. The value of their exports to foreign countries makes no inconsiderable item in our annual trade returns. The streams of old clothes that hour by hour are seductively drained, either by floral exchange, attractive advertisement, or by the downright pestering of 'Old Ikeys,' culminate in the great old-clothes mart in Houndsditch where Hebrews most do congregate. This inodorous spot has been so often described in popular works that people are now pretty familiar with it, by name at least. But having described the fierce contest which ensues over the mounds of old clothes therein daily deposited, our social statisticians seem to have had enough of them, and have proceeded no further. But the true interest in the story of old clothes begins just at the point where they leave off. To the question of what now becomes of them, we might answer that the greater part of them are now about to set out upon their travels, to enter new circles of society, and to see life, both savage and civilised, under a thousand new phases.

"Those that are intended to remain in this country have to be tutored and transformed. The 'clobberer,' the 'reviver,' and the 'translator,' lay hands upon them. The duty of the 'clobberer' is to patch, to sew up, and to restore as far as possible the garments to their pristine appearance; black cloth garments pass into the hands of the 'revivers,' who rejuvenate seedy black coats, and, for the moment, make them look as good as new. The 'translator's' duty is of a higher order; his office is to transform one garment into another—the skirts of a cast-off coat, being the least worn part of the garment, make capital waistcoats and tunics for children, &c. Hats are revived in a still more wonderful manner; they are cut down to take out the grease marks, re-lined, and appear in the shops like new ones. The streets surrounding the old clothes' market are full of shops where these 'clobbered' and 'revived' goods are exposed for sale, and really a stranger to the trade would not know but what they were new goods. There is a department of the market also dedicated to old clothes, for males and females, 'clobbered' and revived. It

is a touching sight to see the class of persons who frequent the men's market and turn over the seedy black garments that are doing their best to put on a good appearance—the toil-worn clerks, who for some social reason are expected to apparel themselves in black, and the equally careworn members of the clerical profession, chiefly curates whose meagre stipends do not permit of the extravagance of new suits of clothes. The ladies' market is a vast wardrobe of silk dresses; but, if we are to believe the saleswoman, the matrons of England are more thrifty than we gave them credit for. 'Servants come here to purchase, sir! No, indeed, sir, ladies worth hundreds of pounds,' was the reply we got to our inquiries as to the class of purchasers. Black cloth clothes that are too far gone to be 'clobbered' and 'revived,' are always sent abroad to be cut up to make caps. France takes the best of these old clothes for this purpose. The linings are stripped out, and in this condition they are admitted duty free as old rags. Russia and Poland, where caps seem to be universally worn by the working population, are content with still more threadbare garments to be cut up for that purpose. The great bulk of our cast-off clothes of all kinds, however, find their way to two markets—Ireland and Holland. The old clothes'-bag of the collectors may, in fact, be said to be emptied out in the land of Erin, as far as the ordinary order of clothes go, while to Holland only special articles of apparel are exported. Singularly enough, the destination of the red tunics of the whole British infantry is the chests of the sturdy Dutchman. There seems to be some popular belief or superstition in that water-logged country, that red cloth affords the best protection against rheumatism, consequently these jackets all find their way to the land of dykes. The sleeves are cut off, and they are made to button in a double-breasted fashion; thus remodelled, they are worn next to the skin, like a flannel waistcoat, by all careful Dutchmen among the working classes. The Irish chiefly favour corduroys, and we suspect the worn-out legs of British pantaloons of this material are cut off and converted into breeches for Pat. Where he gets those wonderful swallow-tailed coats with brass buttons is a puzzle to all the dealers; it is very certain they do not come from this side of the Channel, and it is equally clear they are remnants of costume two

generations back. Our readers will perhaps have noticed the special avidity the dealers in old clothes evince for all kinds of regimentals, full dress liveries, Volunteers' uniforms, beadles' coats, &c. Anything specially splendid in this line is marked by the collector as a sportsman marks any rare and brilliantly plumaged bird, and ultimately it is sure to be bagged by them. One of the largest dealers in London in these showy dresses, once said to us, seeing a Guardsman going along the street, 'A thousand to one that coat comes into my hands.' Really the inevitability there appears to be about the destination of these regimentals, if known to their wearers, should make them very uncomfortable. The dealers would, if they could, strip them off their backs, just as an eel-woman skins an eel. A Lord Mayor's footman's full dress livery is viewed by these gentry with wolfish eyes. These are the great prizes of the profession, and their barbaric splendours are destined for a special market, the West Coast of Africa, where nature puts on her most gorgeous apparel, and the great ones of the land are determined to have something to match. Travellers often tell us of the marvellous appearance of the chiefs of these parts when in full mufti, but we scarcely expected to find our old clothes-dealers the regular *costumiers* of these sable dignitaries, transmitting regimentals, laced liveries, and cocked hats, as regularly to them, as a London tailor sends his clothes to his country customers. And Mumbo Jumbo will not be put off with inferior articles —the slightest blemish in colour or inferiority in cloth is instantly detected and rejected by these semi-savages, hence the greatest care is necessary in catering for their wants. It is just possible that the Lord Mayors for these last dozen years would be able to recognise their own splendid liveries on the backs of a council of these potentates, if they could ever be got together for any purpose whatever. We ourselves saw an assortment of well-preserved liveries of the heir to the proudest throne in the world just being packed for exportation to the grand destination of all fine liveries we have just mentioned. It should be a solace to the parish beadle that his clothes, instead of descending in the social scale like those of ordinary civilians, are destined to flame upon the back of some autocrat who holds the lives of thousands of men at his

disposal, instead of only being the emblems of terror to poor parish boys. The vast majority of the scarlet coats of our officers, that are a little worn, find their way to the great annual fair at Leipsic. There is a belief in the trade that the destination of this bright scarlet cloth is the cuffs and facings of the civil officials in the Russian Government. However this may be, the fact of secondhand regimentals finding their way to the great German fair is undoubted. The pepper-and-salt great-coats of our infantry go to our agricultural districts and the Cape, but the heavier and more valuable artillery cloaks find their way to Holland, and that country and Ireland absorb between them the cast-off clothes of the police. There is one odd item of old clothes that has a singular history. There are still a certain class in the community addicted to the use of silk-velvet waistcoats. This class is generally to be found among the well-to do tradesmen of country towns. The longevity of a black silk-velvet waistcoat is proverbial; it will not wear out. After adorning the respectable corporation of a provincial grocer until he is thoroughly tired of it, what does our reader think is its ultimate destination—the pate of some street German or Polish Jew! In obedience to a Rabbinical law it is not considered right by some of the more conscientious Hebrews to go uncovered, and these secondhand waistcoats are bought up to make skull-caps for their use.

"But old clothes, after they have served the purpose of two or three classes of society, are yet far from closing their career; when they have seen their worst they take altogether a new lease of existence. When old clothes are too bad for anything else, they are still good enough for shoddy and mungo. It is not many years since Mr. Ferrand denounced the 'devil's dust' of the Yorkshire woollen manufacturers; this devil's dust arises from the grand translation of old cloth into new. Batley, Dewsbury, and Leeds have been described as the grand centres of woollen rags—the tatterdemallion capitals, into which are drawn all the greasy, frowsy, cast-off clothes of Europe, and whence issue the pilot cloths, the Petershams, the beavers, the Talmas, the Chesterfields, and the Mohairs in which our modern dandies disport themselves. The old rags, after being reduced to the condition of wool by enormous toothed

wheels, are mixed with a varying amount of fresh wool, and the whole is then worked up into the fabrics we have mentioned, which now have the run of fashion. It is estimated that shoddy and mungo supply the materials for a third of the woollen manufactures of this country. Here is a grand transformation. No man can say that the material of the coat he is wearing has not been already on the back of some greasy beggar. In one corner of the 'Animal products department' in the Bethnal Green Museum the visitor can see hundreds of specimens of this shoddy and mungo—a perfect resurrection of the old clothes from every country in Europe. The cast-off wardrobes of civilised man by a law of commerce are sucked into this country, and mainly into this metropolis, and in return we distribute them in perfect fabrics, destined to go once more the round of civilisation; woollen fabrics are hard to die, and, for all we know, clothes are thus ground up over and over again.

"The final destination, however, of all old clothes is the soil; when art can do no more for much-vexed woollen fibre it becomes a land rag.

"We have pursued old clothes through so many shifting scenes that, having run them to earth at last, here, perhaps it would be as well to leave them; but, no, they once more reappear in our beer. Hops, we are told, of a certain quality cannot be grown without the manure of woollen rags. Thus, the final destination of old clothes after all is the human frame, and we only finally lose sight of them when, instead of clothing this vile *corpus* they are transmuted into the body itself, as we quaff the foaming tankard, or the more genteel bottled bitter of Bass or Allsopp."

In France there used to be until of late years an annual sale of old clothes at the Tuileries. The custom is a singular one, established by the Royal ladies of the Tuileries long before the great Revolution, acceded to by the Empress Josephine, continued under the Restoration, maintained by tho princesses of the House of Orleans, and kept up with great spirit under the reign of the late Emperor. A long gallery which runs along the basement storey of the Palace, looking into the garden, is fitted up from one end to the other with oak wardrobes. This is called the *de froque* of the palace. It was here that the refuse dresses

and the cast-off apparel of the Royal and Imperial ladies who have succeeded each other for the last hundred years in the occupation of the Tuileries were invariably borne when rejected from the floor above. These wardrobe cupboards, numerous and extensive as they are, got generally well filled during the year, and when the four seasons were considered thoroughly over, a sale was made of the whole, where every article was priced beforehand, and visitors were admitted to view and purchase, without the observance of further ceremony than the presentation of an invitation card from one of her Majesty's attendants, to whom the privilege of granting them belonged. The sale was called of late years the "Retour de Compiègne," but had been known under other appellations during former reigns —"Sacrifice de Fontainebleau," "Caprices de St. Cloud," "Joies de la Malmaison"—according to the place whence the Court returned to spend the winter in Paris, and which varied with every sovereign. The sale of the regal wardrobe of the Tuileries was conducted on the strictest principle of equity. The shutters of the long gallery were closed, and it was lighted up from one end to the other by lamps and candelabra, so that the light was stronger than it would be were daylight admitted, as the ceiling is low and the windows sunk deep into the wall. Every article was ticketed, and, of course, no deviation from the original decision could possibly be allowed. A long line of stretchers was placed all down the middle of the gallery, the doors of the wardrobes on either side were flung open, and the visitor, walking slowly down on one side and returning by the other, made choice of what might suit her taste, and inscribing the number it bore upon a card, handed the latter to the attendant in waiting at the door and departed. The stretchers were occupied by the shawls and mantles, the wardrobes by the dresses, the shelves by the under linen, while a sort of counter at the further end of the gallery was filled with the *champignons*, on which were exhibited the bonnets and head-dresses. . . . . The white satin dress, most splendidly embroidered in silver, with the tunic of *bouillonèe* gauze and silver mouches, confined by bands of panceau velvet, in which her Majesty went to the opera with the King Consort of Spain, was not quoted higher than the nankeen-coloured dress and jacket, braided in green,

which was recognised as the uniform invented by the Empress for the drives at Fontainebleau. To be sure, the buttons were of malachite, and set in gold, but the material of the dress could scarcely be considered as bearing any value whatever. The utmost exaggeration seems to exist in the prices put upon the bonnets. In the first place, the article itself is out of fashion almost as soon as seen; in the next, it possesses no resource whatever; and, above all, it is liable to far greater deterioration than the dress. The habit of leaning back in the carriage, which has become so general, destroys the bonnet immediately, and renders it shabby in form, even while still bright and fresh in colour. The proceeds of the sale were given ostensibly to the poor; but the things were generally bought up by the valets and women of the wardrobe, who disposed of what remained unsold to the great dealers in Paris, who again sold them to their customers at immense prices.

Mr. Mayhew, in his 'London Labour and the London Poor,' published many years ago, estimated that there were nearly a thousand persons selling secondhand articles in the streets of London, such as old metal-ware, clothes, boots and shoes, bonnets, old furs, old carpeting, old crockery and glass, &c. Street stalls of these may still be seen in Mile-end, Whitechapel, Wilderness Row, and other localities leading out of Old Street Road, &c.

The extent of this waste-material trade, if I may so term it, throughout the country may be estimated in some degree from the number of persons in the metropolis alone who are more or less interested in it.

A glance over the pages of the last 'London Post-Office Directory' shows that there are upwards of 2100 directly interested in the sale and application of refuse, or waste, and the residues of manufactures. This is necessarily far below the total, for it only enumerates householders, and many in the suburbs are not included:—

MANUFACTURERS, OR DEALERS, IN WASTE IN LONDON IN 1873.

Bladder and sausage-skin dealers	14
Blood driers	2
Bone dealers, bone boilers and crushers	16
Chimney sweepers	180

Coal dust makers	3
Coke makers (Gas works)	18
Cork bed and cork carpet manufacturers	4
Cork cutters	50
Cotton waste merchants	17
Esparto merchants	8
Feather purifiers	12
Fellmongers	15
Felt makers	16
Fent dealer	1
Flock manufacturers	7
Fuel (patent) manufacturers	9
Gelatine makers	12
Glue and size makers	14
Glue piece merchants	5
Glycerine manufacturers or agents	8
Gold beaters' skin makers	8
Grease manufacturers for coaches, carts, railway axles, &c.	32
Guano merchants	17
Human hair merchants and manufacturers	32
Horn and bone merchants	14
Ivory-black and lamp-black makers	13
Lint manufacturers	10
Manure merchants and manufacturers	76
Marine store dealers (rags, phials, and bottles, &c.)	560
Melters and tallow chandlers	46
Mop makers	6
Naphtha distillers	21
Oakum manufacturers	24
Oil refiners and seed crushers	55
Orange peel cutters	2
Plasterers' hair manufacturers	12
Rag merchants	133
Rubbish carters, and road and dust contractors	15
Sand and gravel merchants	14
Sawdust contractors	4
Scum boilers	2
Ship breakers	6
Shoddy manufacturer	1
Soot merchants	3
Tanners	54
Tripe dressers	113
Wardrobe dealers and old clothes' salesmen	337
Waste paper dealers	51
Waste ivory, bone, and tortoiseshell dealers	3
Yeast merchants	16

In 1862 the committee of the London Ragged School set on foot a rag-collecting brigade, with a few trucks to collect waste materials. Its necessity was suggested by the

evidence given before a Select Parliamentary Committee in 1861, when it was stated "that not more than four-tenths of the rags of this country were preserved; and that if the remaining six-tenths could be returned to be re-manufactured, there would be no necessity to go to foreign markets for some twenty-five per cent. of the rags now required for the paper manufacture of England." And if this be true of so comparatively valuable a commodity as rags, must it not be also true to a much greater extent of less valuable, but still more important articles in our commercial economy, such as waste paper, grease, bones, broken glass, rope, carpet, &c.? For instance, what becomes of the envelopes of the three millions of letters passing daily through our post-offices? all of which are worth preserving, for they will fetch from 2*s.* to 3*s.* per cwt. Waste (the produce of wear and tear, developed in spite of, and at the cost of the owner) must be made to a greater or less extent in every household, and if not preserved proves either ignorance of its value in a national (and even in a private) sense, most detrimental to social interests, or else want of confidence in the existing means for its disposal, *i.e.*, by aid of the marine store shops. Now, this latter is the principal cause of waste, the value of which may be estimated at millions—a waste which many families would rather allow, than that their domestics should visit such shops: nay, with many respectable servants the dislike of them is equally great, cases having been known where domestic servants regularly buried fat, bones, and rags given them by their mistresses, rather than be seen going to such places. Moreover, if the whole of the marine store shops of England can only gather *four-tenths* of the most valuable refuse (rags), surely there is ample room for any agency which, by drawing public attention to these important facts, simply asks to be allowed to collect and pay a fair price for the remaining *six-tenths now wasted.*

According to the first report of the brigade it appears that, with only four trucks, the boys had in nine months collected upwards of 82 tons of rags and refuse, besides 50,000 bottles. Housekeepers regarded the operation very favourably.

It is calculated that each 600 houses, containing some 4500 persons, would more than amply sustain one truck, leaving a very wide margin. At this rate it would need

just 640 trucks to compass London alone. The following particulars are furnished in the report:—

The number of boys employed at first was 22, subsequently increased to 34; they, with assistants and sorters, received £424 in wages. The average amount expended daily by each truck was 13*s.* 9*d.*, and the number of separate transactions 9,000, giving an average of about ten per truck daily.

The materials collected were of a most heterogeneous character: cocked hats, hearse trappings, old aquariums, and in one bag 1,000,000 postage stamps: in fact, anything that can be got into or on the top of the truck. In one lot of rubbish was found a Bank of England cheque-book (which was at once forwarded to the bank); in another half a dozen pair of new stockings, which were duly returned, much to the owner's astonishment.

The total collection of the four trucks in the first nine months was as follows:—

	Tons.	cwts.	qrs.	lbs.
Bottles	49,818			
Paper	38	19	1	15
Rags, mixed	9	18	2	22
„ white	2	16	0	8
„ dirty	0	16	3	3
Bones	8	6	0	7
Carpet	3	7	2	7
Cullet	0	11	3	22
Cloth	4	19	0	2
Fat, &c.	5	4	3	2
Metals	5	17	1	24
Rope	1	2	1	27
	82	0	3	27

Also, some £70 worth of stuff not bought by weight. Of this vast quantity, *more than one-half would never have found its way into the market at all, except for the facilities offered by the brigade.*

At first a good deal of clothing was brought in, which was sorted and disposed of to the ragged schools, to be mended by the sewing-classes, and sold at cheap rates to the necessitous poor. But the universal collection for the Lancashire sufferers most effectually stopped the supplies.

Nowhere is the class of waste collectors so developed as

in Paris, where the "chiffonnier" forms a peculiar type, almost unknown elsewhere.

Paris owns, among its street curiosities, a race as distinct from the elements of social life as the roving gipsies who have clung together and run over Europe for centuries. Consequently, its manners widely differ from those of the common run of mankind. These heteroclite beings are a species of night-birds of the human race; everything about them reminds you of dark shades and fantastic silhouettes; they sleep in daytime, and spring out of the earth when twilight sets; no one could say whence they come and whither they go. In times of witchcraft they would certainly have been held up as agents of the dark regions. Their language is not French; their dress is peculiarly unlike anything commonplace. When one of these abnormal creatures comes across a *confrère*, the exchange of a word or sign only betrays their confraternity. Summer is too lively for them. When autumn dries the leaves of the sickly Boulevard plantations, and nankeen vestments make place for furs and winter clothes, and the days become shorter, the chiffonnier appears in his splendour, or rather in his loneliness; scarcely are the lamps lit when an army of men and women take possession of the town, and set about earning the morrow's bread. They move about the deserted streets like a horde of phantoms; the lanterns they hold shine dimly and fluctuate to and fro in essentially supernatural zigzags. The chiffonnier has a basket strapped to his shoulders; he creeps along the asphalte like a wolf in a sheepfold; whoever ignores his attributions would think him bent on grievous mischief; he holds an iron hook, and stops at every heap of rubbish. Parisians are still in the habit of accumulating their refuse before their doors; the iron hook goes to work busily in the cabbage leaf, rag, and broken glass hillocks, while the light of the lantern shows the basket owner what is worth taking; and then the hook transfers the rubbish to the basket over the man's shoulder. This silent *modus operandi* is seldom interrupted unless there be a dog lurking about the precious heaps. The dogs regard the chiffonnier as a deadly foe, and the chiffonnier looks upon the dog as an enemy of his profession, for the animal disturbs the symmetry of the refuse heaps, and seeks his food where he finds

it; chiffonniers and dogs engage in personal encounters, where the rag-seeker's hook generally ensures him the victory; and then the sinister and silent toiler resumes his round—for he affects a special quarter "belonging" to him—and vanishes in darkness when the clocks strike two. He reappears three hours afterwards in the suburban quarters, and finally retires to rest in his mysterious haunts, just when Paris awakes and prepares to erect new heaps of rubbish for his next nocturnal tour. No one seems to be aware of his existence; no chiffonnier is ever seen anywhere but over broken glass and rags; he fears company, and the fact is that company is fast asleep when he wakes up and practises his stealthy industry.

Yet these dirty, repulsive, and uncouth labourers are next to indispensable. What would Paris say if for want of chiffonniers she was deprived of her morning papers? As a colony they are most interesting to study, and in their social utility their place is by no means an inconsiderable one, if it be humble. They supply a whole catalogue of Parisian industrials. The cigar stumps go to the manufacture of Régie cigarettes which shopkeepers favour in the undisturbed belief that they smoke superior Maryland tobacco. Broken glass finds its way to the wholesale dealers in cheap crockery. The old iron returns to its primitive source, and the rags are reserved for the paper mills. There are categories of chiffonniers. Hierarchy exists in this lowest crust of human industry as uniformly as in exalted spheres. The *sédentaires* have their own private *clientèle* of customers. Their rubbish is reserved rubbish, and out of it they make over 5 francs a night. The proletarians of the profession are the *chiffonniers d'aventure*, the independent and poor rag pickers whose property lies everywhere and nowhere, but principally in the gutter. The latters' earnings are proportionately smaller—three francs is considered a prosperous job among them. They reside in gangs in the lodgings of *maîtres chiffonniers*—the patricians of the hook—who shelter them for a few centimes, and buy their produce. The patricians forthwith separate the rubbish into divers departments—rags, old paper, bones, old iron, copper, zinc, lead, glass, broken crystal, crusts of bread, are separated and sent off to different industrials. The cotton and woollen rags are not devoted to the same

object: cotton goes to the paper mills, but the soiled, muddy woollen texture is yet destined to appear on men's backs: it is greatly used in the fabrication of cheap cloth. The *habillements complets* at 40 francs of the *Belle Jardinière* have lain in the mud before they contributed to Anatole's love conquests, and many other attractive articles besides pass through the chiffonnier's basket. An accurate idea of the importance of his trade may be realised when it is known that every chiffonnier collects daily four pounds of rags at the least.

A census of this curious portion of the Paris population was made in 1872 by order of the Préfet of Police, and the results showed that there were 22,500 individuals who live by collecting the refuse of the rest of the population. These 22,500 persons, who mostly make two long journeys per day, from one of the outskirts of the city to its centre and back, collect on the average about 50,000 basketfuls of rags, paper, bones, &c.; the value of the contents of the basket, or *hotte*, being fifteen pence, or, on the whole about £3,000 per diem. Each is licensed by a badge. The number of master chiffonniers is comparatively small—not over 120. They employ 300 workmen, and their annual earnings are roughly estimated at £450,000. This only includes the rags; the smaller rubbish constitutes also a very profitable industry.

However picturesque chiffonniers may appear to amateurs of anomalies, they are a very rough set. The profession has ever been noted for its bellicose instincts. They wash their dirty linen among themselves, but they wash it with a vengeance; and they are the most egregious drunkards of creation. Nor is cleanliness one of their attributes. "Sale comme un chiffonnier" is the truest saying of the French dictionary of proverbs. They delight in blue wine potations; they drink and sleep and fight alternately when they are not busy; and as the town would be far too narrow to contain them and their drunken squabbles, they keep out of sight in the murky thoroughfares of the faubourgs. No mortal could boast of having ever heard them say a word of French among them. *Argot* flourishes in the chiffonnier colony of the Barrière Fontainebleau. Yet one good thing must be said of them—they are honest. Many a necklace, many a jewel, found among their rubbish have been immediately handed to the authorities; and their roughness

excludes not a certain uncouth tenderness of heart: for there are many instances of lost children adopted by the commonwealth and instructed in the art of sorting broken glass and crusts of bread. A society of mutual help has been organised; every chiffonnier furnishes 60 centimes a month towards its maintenance. The society has its own committee and its statutes. Through its agency the heaps of rubbish are divided into districts; each rag hunter has his assigned lot; and a fine or a thrashing is inflicted on the transgressors of this universally recognised distribution. Bakers are so confident in the solvability of these worthies that they trust them to any amount. Of course, chiffonniers have their club. The Pot d'Etain, near the Barrière Fontainebleau, is the famous rendezvous of the essence of the craft. This *cabaret* is worth one's while to see, but visitors must take care to be introduced by a member of the fraternity. The place has been divided into three distinct parts. The first compartment is christened "The House of Peers." It is reserved for the aristocrats—those who can afford a first-rate lantern, a brass hook, and a tolerably clean blouse. The second compartment goes under the name of "The Chamber of Deputies"—specially occupied by a second order of chiffonniers, a shade less respectable than the "Peers." The third room is "The drawing-room of the real *prolétaires*"—a drawing-room of which there is but one sample in the world. This contains the *mobile vulgus* of the *chiffonnerie*—the men who possess neither hook nor basket, and whose poverty or proletarian instincts compel them to use their fingers and a common canvas bag in lieu of the usual implements. In 1858 a revolution well nigh overthrew this antiquated hierarchy. The abolition of castes was triumphantly voted in a great congress of chiffonniers; but habit overruled revolutionary instincts. The keeper of the Pot d'Etain is a prudent man; his customers must pay in advance for anything they take: the tin plates are rivetted to the tables by solid chains; a pecuniary guarantee is demanded for the forks and glasses; and this turns out a good speculation, for the chiffonniers usually drink the equivalent of their deposits. The bluish, sour Argenteuil is served *à la ronde* in a black earthen pot, called in chiffonnier phraseology "the little black father," dispensed out of a pitcher denominated *moricaud*. Victor

Hugo must have framed his "Court of Miracles" of "Notre Dame de Paris" in this singular den.

As long as it will hold together, a hat, be it never so shapeless, retains a certain value in the eyes of the experienced rag-picker. Those Jewish perambulating merchants, whose melancholy monotone of "Old clo'" is as familiar to the inhabitants of London as is the sight of the chiffonnier's hook and bag to the denizens of Paris, will seldom refuse to invest their copper capital in hats. Those ill-treated cylinders, crushed, frayed, and dim, are carried off to be rejuvenated in frowsy back shops. It is wonderful to mark the transformation which the cunning touch of these manipulators can effect; or how their glue and brown paper, their peach-black and dyed rabbit's fur can stiffen and smarten the mangiest old chimney-pot into the semblance of its glossy prime. An old hat, refreshed at this perennial Fountain of Youth, is really a very creditable work of art. "No Old Master," says 'Chambers's Journal,' "worm-eaten and chocolate-hued, disinterred from a garret and furbished for sale to millionaire purchasers, could be touched up with lighter hand or more trembling care. There it is at last—brighter than new, sleek, trim, oily, the sprucest, if not the most durable of hats. A thing of beauty it is, but not for long destined to be a joy of its sanguine purchaser. Among the things which they manage best in France are certainly old hats. French Nathan, for some mysterious reason, is deeper than his brother Nathan of Petticoat Lane in the secrets of the elixir which turns old clothes into new. He never tries the proverbially difficult experiment of placing young heads on old shoulders. But how many, many times has he succeeded in putting old hats on young heads! That French Israelite is a real artist. Nathan's refreshed hats are not dear. At the world famous Marché du Temple an old hat was quoted, on an average, at three francs. Eight sous represent the rag-picker's charge; the rest is for labour, embellishments, and a fair profit. At half-a-crown, the pretty, brilliant thing may be had—a very Faust of a hat. It bears fine weather well, and may figure creditably on the Boulevards for three consecutive Sundays. But at the first downpour of rain, glue, gum, and paint, silk and brown paper, resolve into their original

constituents, and the whole fabric collapses like a dissolving view."

After these general introductory remarks, I shall proceed to furnish some special details as to the economic conversion of waste, ranging the information, for more easy reference, under the three great divisions of Animal, Vegetable, and Mineral Waste.

Animal Waste.

It will be more facile and useful to treat of these animal substances under separate sections:—The carcases of dead animals; the offal of those used as food; the waste from dressing skins and preparing leather, &c.—all have their distinctive and remunerative uses.

Offal.—The allowance for offal in fat cattle is very largely and variedly influenced by the breed of the animal, sex, age, and accidental circumstances. The following figures may be taken as the average medium weight of the offal in fat cattle brought to market:—In general, hide and horns, 4 to 7 stone of 8 lbs.—in rare cases, 8 to 9 stone; tallow, 3 to 10 stone—in rare cases, nearly to 20 stone; head and tongue 2 to 3½ stone: kidneys, 2 to 4 lbs.; back collop, 2 to 4 lbs.; heart, 6 to 9 lbs.; liver, lungs, and windpipe, 1½ to 2 stone; stomach and entrails, 10 to 14 stone; blood, 3 to 4 stone.

As a country grows older and more thickly settled, substances which in former times were but little noticed are brought prominently into view, either because they prove useful or become nuisances. To this latter class belongs the refuse from slaughter-houses. What shall be done with the *fifth* quarter of the animal, is a question that is perpetually assailing boards of health and other sanitary bodies. The tanner makes use of the hide; the shin bones are manufactured into buttons, and the horns into combs. The suet is rendered by the candle-makers, leaving only the head, offal, and blood to be disposed of. A small portion of the latter is used in purifying sugar. The remainder, including the offal, used to be fed to hogs; but public opinion has of late been setting strongly against this method of utilising it, partly because of a growing conviction that such food does not make good, wholesome meat, and partly because of the intolerable nuisance created by the slovenly methods of dealing with the offal—"a

nuisance that," observes an American paper, "has rendered the beautiful suburb of Boston, known as Brighton, a by-word and a reproach." We have been much interested in two methods that are being used in this vicinity for abating this nuisance, and converting these waste products into valuable manures. The first of these is now in operation in East Cambridge, at the extensive pork-packing establishment of Messrs. North, Meriam, & Co. The blood and offal at this establishment had become such an offence to the neighbourhood, that the proprietors were threatened with a perpetual injunction. They have removed the cause of complaint by drying the entire refuse, including the blood. The parts that contain sufficient fat to be worth the operation are first treated in the rendering tank, the clean fat being converted into lard, and the refuse into grease and grease-oil. The scrap which is left, consisting of the bones of the head and feet, and considerable meat, is then thoroughly mixed with the blood, and dried. This is what may be called the purely mechanical method of disposing of the refuse. The other method, which calls in the aid of chemistry, is what is generally known as the Wilson process, and is carried on successfully by Messrs. Upton & Shaw at Brighton, near the Riverside Press. These gentlemen have lately introduced such modifications into the business of bone-boiling as to render this operation almost entirely devoid of offence; indeed, the whole process is attended with less of disagreeable odour than arises from a pot of boiled cabbage. Their business at present consists mainly in boiling the heads of cattle and sheep in order to extract the grease that they contain. For this purpose the heads are collected each day from the slaughter-houses, before they have had time to spoil, and are packed into a large iron digester, where they are boiled under pressure by steam for about six hours. This suffices most thoroughly to disintegrate the bone and tissue, and to set the fat and grease free. The gases from this rendering tank are conducted into a suitable furnace and there burnt. The resulting soup is then run off into two tanks, the scrap added, and the whole mass treated with acid phosphate of lime, containing a large excess of free sulphuric acid. The bone of the scrap is thus in a large measure converted into superphosphate. The product, which is almost inodorous, is then dried by any suitable means.

Both the above methods of utilising offal are patented, but they are none the less interesting, as showing what is being done to convert waste products that have heretofore been a nuisance into a valuable article of commerce.

The pressed animal residues left in making the extract of meat, and the bone, until now employed as a combustible for heating the cauldrons, are susceptible of a commercial value in the production of cereals and forage and, as a consequence, in the fattening of cattle, if they were but dried and shipped to Europe as animal manure. These represent fertilisers which might be applied to more than 500,000 acres of cultivated land.

In all civilised and densely-populated countries, of the animals used for the food of man, it may be said that nothing is wasted, every part that is not eaten being turned to some useful purpose; the refuse fat is converted into tallow or soap, the greater portion of the skin is made into leather, and the scraps, with the hoofs, feet, and membranes, converted into glue, the horns made into various useful articles, and the bones produce phosphorus and manure.

When, in 1854, I first drew the attention of the Society of Arts to the large quantities of animal food wasted in Australia and the River Plate districts, the subject of increased animal food supplies for our home population had not reached the importance it now possesses. The inquiries set on foot by the Food Committee of that Society have resulted in the publication of much useful information. The British people eat more meat than any other nation; and with the progress of industry, and the larger accumulation of population in towns, we find our home supply is quite insufficient, while prices continue to advance. Naturally, then, we turn to those great pastoral countries where meat is a drug, and numerous endeavours are being made, with more or less success, to place within the reach of the meat-consuming people here the good beef and mutton of Australia and the River Plate.

Take the great empire of Russia—what an enormous waste of excellent animal food is there met with, owing to the difficulty of bringing it to a profitable market. With 20 million horses, 30 million head of cattle, and 60 million sheep, besides 10 or 12 million head of swine, the 60 millions of population are not only well fed, but

have a large surplus available, which is only converted into tallow. The production of tallow annually is stated to be about 200,000 tons, of which half is consumed locally. Not only the fat and the bones, but frequently the entire carcase, is thrown into the melting-pot for tallow. The average price of meat in Russia is four copecks, or a penny per pound.

It is certainly tantalising to many hungry mouths, who find meat an expensive necessary here, to know that the South American States have 70 millions of sheep and 22 millions of cattle, which they scarcely know what to do with, except to kill for their skin and tallow; while there are in the Australasian colonies 5 million cattle and nearly 52 million sheep. It is true that, failing in the transport of much of this surplus here, strong efforts are making to draw population to those productive regions, where numerous advantages are held out to immigrants. Our home production of animal food is not likely to keep pace with the growth of population in the United Kingdom. Nine millions of cattle and 31 millions of sheep do not suffice for our 30 millions of people, and compare rather unfavourably with the enormous numbers in more extended but less densely populated pastoral countries.

Unfortunately, in this instance, distance does not lend enchantment to the view, and commercial and scientific men are striving what can best be done towards bringing the surplus food here alive or dead. The cooked meat in tins does not find general favour, and the modes of preserving raw meat at present in use are scarcely more satisfactory.

Horned stock has increased of late in Australia in a more rapid ratio than the population, and the consequence is that the supply of beef being greater than the demand, a market has to be found for the surplus in other parts of the world. The price of cattle is already commonly quoted "at boiling rate," in other words, fat cattle will fetch no more from the butchers than can be realised for their hides, horns, hoofs, tallow, &c., for exportation. Under the old and slovenly system of sending cattle to the melting-pot, it is certain that from one-fourth to one-half of what ought to have been profitably turned to account was wasted. The value of cattle and sheep must in future be measured in the colonies not by the local demand for

butchers' meat, but by the price which can be obtained for the various constituents of the carcase in the markets of the world. The utilisation of this waste animal food has received a large share of attention in the last few years from numerous Australian companies established to prepare animal food in different forms, either as extract of meat, tinned provisions, or dried and smoked meat.

Had any man not many years ago proposed to employ expensive machinery and elaborate mechanical appliances for the purpose of slaughtering cattle and turning their carcases to account, in the shape of beef, tallow, gelatine, and even as food for pigs, he would have been laughed at as a visionary and a dreamer. Yet this is now being carried out, and the result promised is precisely what Dr. Johnson said of the tubs and vats of Thrale's brewery,—"a potentiality of creating wealth almost beyond the dreams of avarice."

I will describe what is done by one enterprising Australian. Mr. J. H. Atkinson's establishment at Collingwood is situated on the west bank of George's River, near Liverpool, New South Wales. The whole premises occupy about 45 acres of land, and the works give employment to from 70 to 100 men. About 25 acres of the land are devoted to the purposes of a vegetable garden, and as such form an important feature in the economy of the establishment, as will be explained hereafter. About 10 acres are occupied by a piggery, holding from 800 to 1000 pigs; and the remainder is devoted to the necessary buildings for the plant and machinery used in boiling down, raising water, tallow-refining, wool-washing, fellmongering, bone-crushing, &c. The machinery is driven by three steam-engines, a large portion of the power being devoted to raising water from the river. In order to be out of the reach of floods, the engine-house is placed at a distance from the stream, and is connected with the pump by a driving-shaft, 700 feet long. No wheeled vehicles, except tramway-trucks and trolleys, are used in this establishment, and for this purpose rails are laid down in all positions where it is necessary to move weights from one part of the establishment to the other—even the food for the pigs being carried into the piggeries on tramways, thus enabling one man to do as much

work as would require three or four under ordinary circumstances.

To make the great saving effected by machinery in the different processes understood, it will, perhaps, be necessary to show the *modus operandi* pursued in slaughtering and disposing of the carcase of a bullock. The beast, instead of being driven into a comparatively wide place, and exposed to the cruel and protracted methods of killing usually resorted to, is brought into a place so narrow that he is incapable of movement or resistance, and despatched by the butcher at once, with the greatest ease. He is then lifted for skinning by machinery, and as soon as the hide, head, hoofs, &c., are removed, the carcase is let down on a chopping-block running on a tramway; it is then cut into convenient-sized pieces, without the necessity of the men handling or lifting the meat, and the trolley chopping-block run on the rails to the other end of the building, where the boilers are. The meat is then lifted from the chopping-block into the boilers by means of endless chains with hooks attached, passing over sheaves, and driven by steam. The boilers are large steam-tight double cylinders, and capable of holding upwards of fifty bullocks at a time. When filled with meat, the orifice in the top of the boiler is closed, and the steam is let on at a pressure of 15 lbs. to the inch. In about seven hours the whole mass of meat and bone is reduced to a pulp. The steam is then condensed, and the tallow floats on the surface. On a tap being turned, it flows into the refining-pans; and when the refining is completed, by turning another tap, it runs into large shallow coolers. These are only about 3 inches deep, but very wide and long, in order that as great a surface as possible may be exposed to the air. When sufficiently cool, by turning other taps, it is filled into casks alongside, and these are run by means of a tramway on to the weighing-machine, and thence to the rail for conveyance to Sydney. The mass of pulp to which both bone and flesh has by the steaming process been reduced, is then removed from the boilers by means of an opening near the bottom, fitted with a steam-tight door. It falls into a powerful press, also running on the tramways, and the strong pressure being applied, a large quantity of highly concentrated soup is extracted; the flesh and bone,

having by the pressure been made into enormous solid cakes, the trolley-press is run into the piggery, and the greaves given to the pigs. The concentrated gravy or soup is then placed in a peculiarly constructed boiler, and reduced by evaporation to such a consistency that, when cold, it becomes solid, previously to which, however, it is run into bladders. It is, when cold, semi-transparent, of a rich reddish-brown colour, and sweet to the smell and taste, almost like confectionery. The first shipment from Sydney of this concentrated soup, which is in great demand in England, was made in June 1862. An average bullock will yield about 20 lbs. weight of this portable soup. Mr. Atkinson was, we believe, the first person in New South Wales to turn this substance to profitable account.

It will be seen by the above that all the operations are carried on with a very small amount of labour. The tallow, gelatine, and other substances, are scarcely touched by the hand of man, from the time the beast is killed, until its remains are on the way to market and the pig-yards. The above account applies to cattle which are wholly boiled down. The prime portions of the best beasts, however, instead of being carried on the tramway to the boilers, are run off to the salting-house. The process there need not be described, further than that every particle of bone is extracted previous to the meat being salted. The leaner portions, not suitable for the casks, are cut into strips, and made into what is known as *charqui*, or *tasejo*, a South American name for dried or jerked beef. Each bullock will yield on an average about 100 lbs. of *charqui*, and the market for it is understood to be practically unlimited.

I need not go into the details of curing the hides, drying and smoking the tongues, extracting the oil from the hoofs, preparing the horns and leg-bones for the English market—or into the fellmongering, or sorting, washing, and scouring of the wool—for large numbers of sheep are slaughtered, as well as cattle. From the abundance of water, however, all these processes are carried on with a degree of cleanliness and an absence of offensive smells most surprising. The paved floors are inclined from the centre of the building on each side, and being frequently

flushed, are almost as free from impurity as the surface of a dining-table. It will be seen from what is above stated that every part of the beast is turned to aceount. All the blood and offal, as well as the greaves, is devoured by the pigs, and thus turned into pork. The solid manure is carefully scraped up and taken to a distance, where it is allowed to ferment and decompose. It is then exeeedingly strong, almost equal to guano for gardening and agrieultural purposes, and is disposed of readily to the neighbouring settlers for about 10*s.* per load. The liquid manure, of which, from the quantity of water used, there is a very large amount, is run off in pipes to the garden above referred to. It is then carried through the grounds by ditches or canals, and spread over the surface, and is the only description of manure made use of there in the growth of vegetables, &c.

Steam-pipes are carried to almost every part of the premises, so that water of any degree of temperature, for the scouring of wool, &e., can be had at all times wherever it is wanted; and so great is the supply of steam, that a 400-gallon tank can be made to boil in a quarter of an hour. The steam-power, when not engaged in driving the machinery or for heating purposes, is employed in pumping a supply of water from the river into a reservoir. The main building—80 feet square—is surrounded with smaller ones for wool-sorting, fellmongering, and coopering, all the casks used being made on the premises. Tho establishment is capable of slaughtering and disposing of nearly 1000 head of cattle weekly, exclusively of sheep and pigs, and thus affording employment for a very largo amount of labour and capital.

During the year 1870 thero were 290,696 sheep slaughtered at the various boiling-down establishments in New South Wales, 74 cattle, and 1042 pigs. The tallow produced was 87,708 cwts., of which the metropolitan district consumed 42,513 cwts., a large portion being obtained from the refuse in the butehers' shops.

The foregoing remarks have almost exclusive reforence to horned cattle, but I shall be much surprised if, in the course of a very few years, they aro not equally applicablo to horse-stock. Already tho Australian colonios are being overrun with a raco of useless, weody scrubbors, which,

being of no value as horses, are fast becoming a nuisance. Horse-grease has been discovered to possess superior qualities to almost any other fatty substance for oiling machinery, and is now quoted in the London market as worth from 30*l*. to 35*l*. per ton. The other portions of the carcases may be applied to a variety of useful purposes, and the owners of a description of stock now nearly unsaleable at any price, may feel assured that a respectable minimum value will soon be arrived at, below which there is no danger of their animals receding.

The large accumulation of bones and other animal refuse from butchers' boiling-down, and meat-preserving establishments in Australia, has created extensive factories for converting these waste products into valuable fertilisers. The manufacture of these artificial manures is now conducted on a very large scale, and a considerable local and export trade has resulted therefrom. About eight different kinds are usually made, consisting of bone-dust, bone-meal, animal guano, superphosphate, half-inch bones, potato manure, phosphoric-potash manure, and special manures for sugar and coffee. The chief ingredient in each of the above is bone, which varies in value thus:— "Green," or butchers' bones, in consequence of their containing the largest proportion of fat, reach the highest value, viz., from 3*l*. 10*s*. to 4*l*. per ton. Marine-store bones consist of a mixture of household and other bones, which are picked up by collectors; value, 2*l*. 10*s*. to 3*l*. per ton. Boiled or steam bones vary greatly, according to the time they are boiled or steamed. If only partially boiled, with some fat left in them, they are worth about 2*l*. 10*s*. per ton; if over-boiled, their value is about 2*l*. per ton; if steamed and perfectly dry, they fetch from 2*l*. 10*s*. to 3*l*. per ton. There are also the bones of sheep's heads and trotters. If collected when fresh they are worth about 2*l*. 5*s*. per ton; when dried, their value is reduced to 1*l*. or 1*l*. 10*s*. per ton. The above quotations are subject to the laws of supply and demand; they may, however, be taken as the average of the ruling prices in Victoria. The next most important source for manure is the refuse of boiling-down and of meat-preserving establishments. These differ, in so far as the first contains less bone but more meat than the second. At the boiling-down works, the sheep are

steamed in closed vats of wood or iron, for the purpose of gaining the fat or tallow. The following plan is adopted at the Australasian Manure Company:—A large three-storey building is close to the sheep-yard, from which an inclined stage is constructed to the top-floor, and up which the sheep are driven. The killing is done on this floor, on which are placed three vats, for holding respectively 550, 350, and 300 carcases. When the vats are filled, steam, at 25 lbs. pressure, is forced thereinto for a period of eight hours, by which time all the fat is separated from the flesh and bones. Water is now pumped into the vat, which causes the tallow to float on the surface, and it is then run off through the tallow-cock into a large cooler on the ground-floor, where it is allowed to cool, and any water or other matter to settle at the bottom. The tallow is then run into casks, care being taken that it should not be hot, and that it be well stirred before the casks are coopered up, and also that the gravy comes off before the tallow is run in. What is left in the vat is the refuse. In the manufacture of bone-manure, the bones, in whatever state they come, are hoisted by engine-power to the top-floor, where they are filled into vats, and steamed. Green bones require 40 lbs. pressure of steam for three-and-a-half hours; dry bones, sheep's heads, and trotters from two-and-a-half to three hours. In all cases the bones must be turned out white and brittle. After the process of steaming, the tallow and gelatine extracted from the bones are blown off through the bottom cock. The gelatine comes out first, and is run into a large wooden tank; the tallow follows, and is conveyed into a wooden vat on the bottom-floor, where it is re-boiled with a little sulphuric acid, to separate the fat from the gelatine; the latter is preserved, as it forms a valuable addition to the manure. The bones having been steamed, are drawn from the vat on to the second-floor, where they lie in a heap till they become mouldy and perfectly dry, which occupies from one to three weeks. Gelatine, the principal source of ammonia, is thrown upon the heap, by which the value of the manure is enhanced. The bones are now taken to a mill, containing a pair of rollers with large teeth, by which they are partially crushed. They are then hoisted, by a chain of iron buckets, into the "centri-

fugal revolving-mill," which discharges its contents into a sieve or dresser, also revolving, and allows the stuff which is fine enough to fall into a shoot, which carries it to the bottom-floor, from whence it is conveyed to the storeroom. The stuff, which is not fine enough, empties itself again into the buckets, which carry it a second time to the upper mill; and so on till it is crushed fine enough to pass through the holes on the "dresser;" these vary in size for every kind of manure, but average about three-sixteenths of an inch. The bones thus manufactured yield a good saleable bone-dust. In some instances sulphuric acid is added to the dust for making the phosphates soluble. The value of this manure is 6*l.* 10*s.* per ton. Bone-meal is made the same as bone-dust, only the holes in the dresser are covered by a fine wire-gauze, which makes the meal much like flour. Its value, 8*l.* per ton. Animal guano is entirely manufactured from the refuse of the boiling-down and meat-preserving establishments, and has only to be perfectly dry to be fit for the mill. Value, 5*l.* 10*s.* per ton. Half-inch bones are manufactured by sending the residue which empties itself out of the dresser through a sieve having half-inch holes. Value, 5*l.* per ton. Phosphoric-potash manure, potato manure, and special coffee and sugar manures are fertilizers, of which the manufacture is a trade secret, and are scarcely important enough to be particularised. Superphosphate is an addition of sulphuric acid to bone-dust. This manure is of great importance in Europe; but owing to the high price of sulphuric acid, it cannot at present compete with the home manufacture. Its value is about 10*l.* per ton. All these manures should lie in a heap for nearly three months before they are sent out, as the natural heating process they then undergo greatly increases their quality and value. It is well in the steaming of bones to classify them, as the tallow of each kind of bone gives a different market value. The average price for bone tallow is from 26*l.* to 28*l.* per ton, casks included. The harder and lighter the colour of any kind of tallow, the more it will be worth. The tallow from fresh sheep's heads is worth from 30*l.* to 31*l.* per ton. Sheep's trotters should always be steamed by themselves, or, better, boiled in an open copper, by placing a steam-pipe therein, and adding enough water

to cover them. The oil will come to the top, and should be carefully skimmed off, and then passed through a clean cloth into casks to settle. The oil, known as neatsfoot-oil, is worth about 4*s.* per gallon. It is used for tanning and saddlery purposes, as well as for machinery. The first exportation of bone-dust from Victoria commenced in 1865, and was valued at 79*l.*; in 1870, 3353 tons were exported, valued at 22,691*l.*; and manure, valued at 10,303*l.*

The 'Daily Telegraph,' in an article recently published, states:—"There is a vast quantity of animal 'offal,' as much as serves to stock at least half-a-dozen shops, at which a brisk, and no doubt a very profitable, business is done daily. [There are, in fact, 113 tripe-dressers and vendors of this offal in London.] Nor is the favour with which the said food is regarded due to any endeavour on the part of the vendors either to disguise its real nature, or by skilful artifice to make it appear nicer-looking than it naturally is. Undoubtedly, the heads and 'plucks' and hearts, suspended in huge crimson bunches, do look grimly offalish displayed in the shops of the tripe-sellers; and it is hardly calculated to propitiate the scruples of the fastidious to observe that no pains are taken to keep far apart the offal that is human food and the horse-flesh in which the tripeman likewise deals, vending it as sustenance for cats and dogs. I think that the sheep's heads make the most ghastly display. At one shop there was a huge bench standing outside, and on this were heaped, I should say, at least fifty mutton craniums 'in the blood,' just as they were severed from the carcase. The rough-and-ready offal dealers had not taken the trouble even to strip off any of the woolly skin; that as well as the neck part was dabbled red, some of the heads had horns and no ears, some had ears and no horns; and there were half-a-dozen poor mothers busy overhauling the pile, fishing out heads that looked promising, handling them, turning them about, and holding them up by a bit of skin, or a red horn for more critical investigation of their 'meatiness.' Tenpence appeared to be the ruling price for a sheep's head; but this was without the tongue and brains, deprived of which there seemed to me to be but a very indifferent tenpenn'orth remaining. The tongues were retailed at three pence each.

Bullock's liver seemed more in request than sheep's, probably on account of its comparative cheapness; but besides those enumerated were exhibited many items of offal still cheaper than the bullock's liver."

Neatsfoot-oil and trotter-oil are products obtained in the process of boiling down calves' feet and sheep's feet. Trotter-oil is sometimes sold as hair-oil.

After the hair and hoofs have been removed from the feet of oxen, they yield, when boiled in water, the peculiar fatty matter, called neatsfoot-oil. It is not subject to rancidity, and remains fluid at 32°. When part of its stearin has been abstracted, it is used for various purposes, and, among them, for oiling steeple clocks, which require, in consequence of the cold to which they are exposed, an oil not liable to solidify. It is also used for softening leather.

The bones are worth as much as the oil, being useful in the manufacture of buttons, of tooth-brush handles, of ferrules, &c. The proper way is first to strip off the tendons, which should be steeped with lime preparatory to making glue of them; secondly, after washing, boil the leg and hoof well and skim off the oil; thirdly, throw the bone into cold water, and subsequently keep it from the sun and heat to prevent cracking; fourthly, preserve the hoof for the manufacture of Prussian blue, or for the manufacture of buttons and other articles, in heated matrices by the new process; and, fifthly, apply the residuum in the boiler and in the lime-vat to the soil.

In the process of boiling down the carcases of hogs for lard, glue is made from the hoofs; and the refuse from this and other offal is employed in the manufacture of prussiate of potash, to the product of which also contribute cracklings, or the residuum left in expressing the lard. The prussiate of potash is used extensively in the print factories of New England for dyeing purposes. The blood of the hog is manufactured into Prussian blue. The skin of the pig is comparatively of little value. An old hog may so far perfect his skin as to cause it to become useful as a slipper, but no general supply of any real utility to the shoemaker can be derived from this source.

Even hog skins suitable for saddlers' work have scarcely any marketable value in the north-western States of America, the great seats of hog-slaughtering; the largest

and best skins can readily be contracted for in Chicago at a shilling each. Hog bristles can be supplied in almost any quantity at a price equal to the cost of gathering them. Shank and leg bones for button manufacture, hoofs and horns for comb manufacture, and rough bones for agricultural use may be quoted free on board at Chicago as follows:—

Thigh and leg bones ..	£2 per 1000.
Hoofs	£2 to £2 10s. per 2000 lbs.
Horns	2*d.* to 2½*d.* each.
Rough bones	£1 per 2000 lbs.

The annual supply of shank and leg bones, suitable for manufacturing purposes, at St. Louis, Chicago, and Milwaukie would exceed 1,000,000; the supply of hoofs, 200 tons; of horns, 1,000,000; and of rough agricultural bones, 2000 tons. Supplies of hoofs and horns have been sent direct from Chicago to the Devannah Comb Company at Aberdeen, Scotland: but attempts to make shipments of rough bones have failed, in consequence of the high freights demanded by lake vessels. Recently attempts have been made to burn the rough bones for sugar-refining purposes, but the experiments have not succeeded fully.

What becomes of the tallow? is a question raised by the 'Grocer' in an interesting article. It states that every application of tallow has been invaded, first by vegetable, and then by mineral novelties:—"The beauty, cheapness, and brilliancy of the paraffin wax and the mineral lamp oils have brought them into use everywhere, among all classes, and in all countries and situations. The tallow candle appears to be going the way of the old tinder-box; and tallow is only used as an exceptional high-priced and luxurious lubricant. Thus it appears that the demand for tallow is wonderfully diminished, while the Australian supplies are still increasing. How is it, then, that the price of tallow still keeps up? What answer can we give to the question? What does become of the tallow? It is well known that vast quantities of kitchen-stuff and Australian fat, which formerly were consumed by the tallow-chandlers and soap-makers, have lately found their way into the empty Dutch and other butter-tubs which are now bought up more freely than of old; that much of this purified fat has been shipped to Holland and other butter ports for purposes of admixture; that although the mon-

strous newspaper nonsense about making butter from Thames mud is utterly baseless, the river Thames has borne upon its bosom many and many tons of white fried fat that has been prepared within a moderate distance of its banks. It is a significant fact that, during all last winter, the usual consumption of butter was continued in London, &c., although the excessively dry summer which preceded it had decreased the English dairy produce very considerably, and had diminished the supply from other sources materially. At the present moment fresh butter is offered for sale in some parts of London at 1*s.* per lb. retail, while the farmers are selling their produce wholesale at 1*s.* 4*d.* to 1*s.* 8*d.* This one-shilling fresh butter is quite a different article from the cheap Australian butter that has been recently imported. Artificial butter has a special interest and importance in connection with this subject, for here we have an article of primary importance, which, if honestly dealt with, may become an immense blessing to mankind, especially to the poorer classes, but which otherwise may be kept in the dark, held back from its legitimate uses, and made simply to serve as a means of fraud by the dishonest, and as an ever-irritating source of distrust and vexation between the honest dealer and his customers. While such false butter is sent away to Holland, to Ireland, &c., to be mixed with the genuine article, the shopkeeper is liable to be deceived; he may, with the best possible intentions, and in spite of every precaution, be supplying his customers with an article which is quite different from what he supposes he is selling—for in this case the analytical chemist cannot help him, whatever he may profess to do, the difference between cow-butter and the mixed butter being so small as to pass beyond the reach of chemical detection. The remedy is simple enough. Let any enterprising capitalist connected with the trade commence openly and fairly the manufacture of artificial butter, to be made and sold as such. Let him, in the first place, use materials which will not be offensive either to the imagination or the palate (such, for example, as clean and wholesome Australian mutton fat); in order to secure the confidence of the shopkeepers and the public, let him open his works to visitors, and then let him sell his butter under an honest name, and we believe that he will be able to over-

come all prejudice, and in a short time do a handsome business, with good profits, and have the satisfaction of knowing that he has enabled the poor man and the poor man's child to enjoy a cheap slice of bread-and-butter, and many other luxuries of which butter forms a part, and also that he has destroyed a nefarious system of false dealing; for there is a certain peculiarity about the artificial butter which will become understood when the trade is familiar with it, and this will finally aid its detection in admixture. We have already given some attention to the subject, and have tasted some purely artificial butter, which was really good, sweet, and pure. Bread-and-dripping are commonly given to children in lieu of bread-and-butter, and the artificial butter, properly prepared, is really a purified dripping of very superior quality. The artificial butter has the further advantage of not becoming rancid, however long it is kept, and thus it requires no salt. With both articles honestly placed before the purchaser, viz., the dairy butter and the butter made from animal fat, he could choose which he preferred, and pay the fair value of either."

The Economic Uses of Dead Animals.—On almost every farm, one or more large animals—a horse, a cow, or a bullock—dies in the course of each year through disease, accident, or age; and every farm loses pigs, calves, or sheep in the same period. The disposition of the carcase is frequently a source of perplexity to the farmer. If a large stream is convenient, they are frequently thrown into it, to offend the sense of sight and smell, as well as pollute the waters. Occasionally the defunct animal is buried; but more frequently dragged to the nearest woods, where it rots, impregnates the atmosphere with offensive smells, and furnishes a rich feast to the crows and other carrion feeders. This is all wrong, and in these days of high prices the manurial value of a dead horse or cow is too great to justify such waste. Many farmers will sell a worn-out horse to the tanner for a few shillings, while the actual worth of the carcase, for manure, is ten times that amount. Every particle of it—hair, hide, hoofs, bones, flesh—will assist in adding to the value of crops. The easiest and most profitable method of disposing of a carcase is to cover it thickly with fresh soil, with which a portion of quicklime has been mixed. After thorough decomposition

has taken place, the whole mass should be made into a compost with fresh soil, after which it is ready for application to the soil. It is stated by Dr. Wilson "that every pound of animal flesh will impregnate ten pounds of vegetable mould; or, taking our soils as they usually occur, one pound of flesh, fish, blood, wool, horn, &c., can fertilise three hundred pounds of common loam." These are striking and well-authenticated facts, and they appeal with powerful force to the farmer, who, hitherto, has permitted this valuable fertilising material to go to waste. But I will point out a simple way by which the carcases may be turned to useful and economical purposes. First, skin the animal, as done in a slaughter-house; sprinkle well the skin with salt on the fleshy side to preserve it from putrefaction: then roll it up, when it may be kept till a convenient opportunity for disposal to a tanner. The carcase is then cut up into pieces of half a hundredweight, put into a boiler with water, and boiled for twenty-eight hours, by which time the flesh will have so softened that the bones can be taken out. Before doing so, whatever grease there is will float on the top; this, when skimmed off, will be found superior to any other grease for lubricating machinery and cart-axles.

The boiled flesh may be cut up and mixed with the farm-yard manure, and the liquor or soup might be used to ferment bones or run into the liquid-manure tank. The quantity of each ingredient depends entirely upon the size and condition of the animal. Taking an ordinary-sized farm-horse, in working condition, weighing 15 or 16 cwts., the approximate value of the products may be assumed at 28*s*. to 30*s*. 84 lbs. is the greatest weight of dry bones the largest horse will yield.

The number of army horses that die in the hands of the Governments, and are killed in battle, is so great that if they were all buried, it would require hundreds of acres of land for the purpose. These defunct animals are bought by parties and turned to a very useful account. They are divested of their hides, which, after being salted, are disposed of to tanners. The hair of the manes and tails is washed and dried, and the best quality manufactured into haircloth. The residue is used in various articles of commerce, but chiefly as curled hair.

After the hide is removed the body is divided into small

parts and conveyed to tanks. Each tank has a steam-pipe connected with it, and these pipes are supplied with steam from a boiler of great capacity and power. The tanks are filled with flesh, and water is let into them. For nine hours the meat is steamed. At the end of that time the covers of the vats are removed, the oil is taken from the surface, and, after being cooled and strained, is put into barrels and sent to market. It is considered to be equal to any for lubricating purposes, except the finer fish oils. It is also used largely in soap-making.

The steaming process having been completed, the water is let out of the tanks, and the residuum of the bones and other fibrous matter thrown out upon a platform, where it undergoes a raking process, which separates the large hard bones from the small and softer ones. The hoofs are then selected, the shoes taken from them and sold as old iron; the shoeless hoofs are sold to the horn-combmakers and others, where the parts suitable for combs are worked up, and the residue made into glue. When the large bones are separated and seasoned, they are ground into the fertiliser known as "bone-dust."

The softer bones are taken, together with the pulp, and placed in sheds, where it lies for a certain length of time under the action of sulphuric acid and other chemicals. It is then spread out in a dry atmosphere until all moisture evaporates, when it is ground to a coarse powder, and packed in barrels or sacks ready for use.

By artificial means this fertiliser can be prepared for market in thirty days, but it is not reckoned to produce so good an article as when prepared by the usual method, which takes an average time of four months. In quality it ranks next to Peruvian guano, and readily commands from 11*l*. to 12*l*. per ton.

It will thus be seen that there is not a particle of the carcase of a horse wasted, everything being turned, apparently, to the best possible account. There are several of these establishments in the United States, but none so extensive as one on the west bank of the Potomac, about midway between Long Bridge and Alexandria.

It is stated that about 8000 horses die annually in New York, or about 22 per day — an exaggeration probably. Each dead horse is considered to be worth 17½ dollars. His hide is sold to the tanners for 6*s*. or 8*s*.; his bones are

burned, and sold to the sugar-refiners for refining purposes, and to the farmers for manure; his meat is pressed, and the grease used by the soap and candle makers; while the entrails and remnants are fed to the hogs to make pork for home consumption.

The following is from an Australian paper:—"What is to be done with bush horses? is a question that has often presented itself to the contemplative mind. They have been sold out of the pound at a half-crown, at a shilling, and at sixpence per head. A discoverer, who deserves the thanks of the community, has introduced the practice of boiling them down. As there is no place where there is more material for this species of manufacture than at King's Plains, I am glad to be able to give information of the production here of a quantity of horse-oil. Will the changes of fashion ever make it hair-oil?"

A large quantity of manure is made in Lyons by boiling down the flesh of horses and other carcases in close vessels to a pulpy consistence. This material is then mixed with bone-dust, exhausted animal charcoal, ashes, or gypsum, according to circumstances, and is afterwards dried and powdered. Such manure contains 7 or 8 per cent. of nitrogen.

In London upwards of 400 horses die weekly within a radius of five miles from Charing Cross, and the flesh is boiled and chiefly sold as food for cats and dogs within that area. A dead horse will fetch from 20*s.* to 50*s.*, or an average value of 35*s.* The total weight in pounds of the carcase is from 672 lbs. to 1138 lbs., or an average of 905 lbs. The following is the comparative value and uses of the several parts in the metropolis:—

Hair, about 1 lb., worth 1*s.* to 1*s.* 3*d.*; used for haircloth, mattresses, bags for crushing oil-seed, plumes, &c.

Hide, 50 lbs., worth 12*s.*; used for tanning and covering tables, &c.

Tendons, 6 lbs., made into glue and gelatine.

Boiled flesh, 252 lbs., worth 31*s.* 6*d.*; meat for cats, dogs, and poultry.

Blood, 60 lbs.; for prussiate of potash and manure.

Intestines, 25 lbs., worth 1*s.*; for covering sausages, &c.

Grease, 28 lbs., worth 4*s.* 8*d.*; for candles, soap, &c.

Bones, 60 lbs., 4*s.* 6*d.* per cwt.; used for knife-handles, manure, phosphorus, and superphosphate of lime.

Hoofs, 12 lbs., 8*s.* per cwt.; made into pincushions and snuff-boxes when polished, or for gelatine, glue, and prussiate.

Old shoes, 10 lbs.; worth 5*s.* to 10*s.* the cwt. for old iron; sometimes re-worked up into shoes.

Horse-flesh as food.—The sale of horse meat has now become a legalised and recognised trade in many of the Continental States. The Prefect of Police chose from among eminent and competent judges a commission to inquire into the quality of the flesh taken from horses which had died, or been killed, in Paris and its environs. The commissioners were, like the general public, at first prejudiced against horse-flesh, and they indicated that prejudice in the terms of the report:—

"*Nous ne pouvons découvrir* que cette chair ne soit *fort bonne et fort savoureuse;* plusieurs membres de la commission en ont mangé, et ils n'ont pas trouvé qu'il existât entre elle et celle du bœuf une différence sensible."

M. Geoffrey St. Hilaire, professor at the French Museum of Natural History, delivered two lectures on the advantages of bringing horse-flesh into use for food. There is no reason, he declares, why horse-flesh should not be eaten; like the ox and the sheep, the horse is herbivorous, and no deleterious element enters into its food or structure. Its flesh, besides, is full of azote. The ancient Germans and Scandinavians had a marked liking for horse-flesh. They preserved a certain race of white horses to be sacrificed to Odin, and, after the sacrifice, they boiled the flesh and feasted on it. The introduction of Christianity put an end to this custom, and probably led to the aversion to horse-flesh which is now generally manifested in Europe. The nomad tribes of Northern Asia make horse-flesh their favourite food, though they have numerous flocks of oxen and sheep. In spite of the dislike of horse-flesh in modern Europe, the Danes recommenced the use of it. During the siege of Copenhagen in 1807, the Government formally authorised the sale of it in butchers' shops, and since then it has been constantly sold: there is even in that city a privileged slaughter-house for horses, placed under the surveillance of the Veterinary School, and horse-flesh is sold in it at the average price of 12c. the pound. Parent Duchâtel, an esteemed writer, asserts that large quantities

of horse-flesh were formerly introduced into Paris on different pretexts. Huzard, an eminent veterinary surgeon, states that, in the scarcity which followed the Revolution of 1789, the greater part of the meat consumed at Paris for six months was horse-flesh, and that it caused no ill effect on the public health. The distinguished army surgeon, Baron Larrey, made his wounded patients eat horse-flesh in the campaigns of the Rhine, of Catalonia, and of the Maritime Alps, and he ascribes to it the cure of a great number of his sick in Egypt. From all these facts, and numerous others, M. Geoffrey Saint Hilaire insisted that the horse, in addition to the services which it already renders to man, can be made to supply cheap and nutritious food. He contends that, while so many of the inhabitants of France scarcely ever eat animal food, it would form a valuable addition to their food resources—an abundant one also; for he finds that the number of horses which are killed, or die naturally, every year in France would supply two millions and a half of ordinary rations of meat; and he winds up his argument thus: "Singular social anomaly! Some day society will wonder it was so long submitted to. Millions of Frenchmen are deprived of meat, or eat it six times—twice—*once* a year—and in presence of deprivation, millions of kilogrammes of good meat are every year abandoned to industry for secondary purposes, thrown to hogs and dogs, or cast into the sewers!"

Since 1860, when the first slaughtering of horses took place for food in Paris, under the patronage of the Committee of Horse-flesh, the consumption of this meat has been steadily increasing. The committee has had to contend with the prejudice of the ignorant and the indifference of the better informed; but it has succeeded in making horse-flesh accepted as food throughout France, especially at Nancy and at Paris.

At the time of the siege of Paris there existed in that city thirty butchers who sold horse-flesh when the Prussian armies had invested Paris and rendered victualling impossible. Some persons thought, by using horse-flesh, resistance might be prolonged, and they persuaded their friends to overcome the general dislike to this new food. The rationing of butchers' meat, whilst the sale of horse-flesh was free, served to give it a powerful impulse. Those

who preferred the meat-ration were interested also in popularising, as much as possible, horse-flesh, since the number of these animals in Paris was considerable, and held out a prospect of a large addition to the food supply. From the researches of M. Decroix, chief veterinary surgeon to the Republican Guard of Paris, it appears, before the Administration had decided to take an account of the quantity of horse-flesh available, that there were, at the beginning of the siege, approximately 100,000 horses, including those in the army. Some considered this estimate too high by 20,000. In reckoning 30,000 horses for the army and other necessary services, there would then be 70,000 left. Assuming that, on the average, each horse would supply about 500 lbs., the 70,000 horses would give about 35 million pounds of fresh meat. In distributing this quantity at the rate of less than two ounces daily to each person, as was the case with beef, there was horse-flesh for 175 days, children receiving only half rations. The saving made upon these served to increase the rations for the soldiers encamped around the fortifications; but, unfortunately, there was only a tardy resort to the necessary measures. At the beginning there was a shameful waste and a great abuse, which it became necessary to repress. From the 15th of October, the Minister of Agriculture and Commerce, at the request of the committee for the use of horse-flesh, and with a view of preventing the rise in the price which certain butchers were charging, fixed the tariff for horse-flesh at about 9*d.* a pound for prime parts, 7*d.* for the second qualities, and 4*d.* for the third. Notwithstanding the increase of the price of horses, from 1*l.* to 24*l.*, the tariff did not alter for upwards of a month; it caused the closing of several butchers' shops, which could no longer be kept open, owing to the tariff price as compared with the cost price. On the 10th of October the Minister of War, at the request of the Minister of Agriculture, ordered that every day each regiment should make known the number of horses unfit for service and suitable for food. On the 17th of October the horse-meat committee asked for an account to be taken of all the horses in Paris, with the double object of killing and salting those in excess of the number which could be conveniently supported (the taking an account of hay and oxen had already been done), but this account was not ordered till a month later, by a

decree on the 25th of November. On the 23rd of October, the committee asked the Minister to decree the rationing of horse-meat, in order to prevent the waste consequent on the unlimited consumption, and pointed out that there were about 400 horses killed daily. Some days later, a committee was charged with marking all horses suitable for killing, and limiting the number to be killed to 300 daily; but every butcher was free in the sale of his meat who contracted for supplying the consumer at the same time with beef. On the 11th of November a decree appeared which reserved to the State the right of buying horses for food, and dividing the meat and the offal, as had already been done with beef, among the twenty arrondissements. From this time, waste, clandestine destruction, and the exorbitant rise in price, was considerably checked. The consumption of horses for food for Paris during the siege was—September 1870, 984 horses, 15 asses; October, 12,420 horses, 329 asses, and one mule; November, 7372 horses, 274 asses; December, 15,000 to 18,000 horses; January, 15,000 to 18,000 horses; making in round numbers from 50,000 to 60,000 horses which had been slain to supply the food of Paris. But these figures are not precise, for, in spite of the decrees of the authorities, clandestine slaughtering, though it decreased very much, did not cease entirely. It is not possible to give the exact figures, Government not having yet stated them precisely. But while the Parisian population was fortunate enough to find in horse-flesh a means of prolonging resistance to their enemy, it must be acknowledged, without wishing to lessen the merits of horse-flesh, that it occasioned amongst numerous persons disgust and internal complaints, proving that it has its drawback as a regular article of food. Nevertheless, it may be remarked that this opinion must be received with reserve. The manner of preparing the meat has a marked influence. Cooked as a *ragout*, horse-flesh occasions a derangement of the health, which is never observed amongst those who have eaten it roasted. It is as well also to remark that, if internal complaints were very prevalent during the siege, but few stomach complaints existed; from which it may be considered that the food, strictly rationed, did not allow overloading the stomach with too large a quantity of food. The use of meat killed only a few hours before being eaten,

the want of vegetables, and the small proportion of bread, often of an inferior quality, which the Parisians had at their disposal, must also have had an influence on the health of a population whose dietary was completely upset.

M. Decroix, who for ten years has occupied himself with demonstrating the wholesome properties of horse-flesh and introducing it into general use as food, has published some curious statistics as to the aggregate consumed in Paris. The decree authorising and regulating the sale of horse-flesh was issued in June 1866. On the 9th July the first butcher's shop for its sale was opened. The following figures show the gradual extension of the consumption:— Six months, 1866, 902; 1867, 2152 horses, asses, and mules; 1868, 2400; 1869, 2758; 1870 and 1871, 65,000. To these figures, obtained from information procured at the central markets and the civil slaughter commission, must be added, according to M. Decroix, at least 5000 slaughtered and consumed by the regular army, and nearly as many more killed beyond the barriers, or clandestinely in Paris; so that, in round numbers, about 70,000 horses were eaten during the siege. In the second half of 1871, 2130 were used, and in 1872, 5732. We may judge from this, it is remarked, what an immense resource horse-flesh could add to the animal food consumed, if the prejudice against it were entirely overcome. The total number of horses, asses, and mules in France is about three million head; and the mean duration of life among these is say twelve years: hence the number of animals that might be handed over to the butcher, deducting one-fourth for unhealthy animals, is nearly 200,000 annually, which, taking the mean weight of meat at 440 lbs., would give about 88,000,000 lbs. of food.

According to M. Decroix's full statistical tables, published in the 'Bulletin of the Society of Acclimatation' for February 1873, page 98, there had been slaughtered in all Paris from the opening of the first horse butcher's shop in July 1866, to the end of December 1872, 83,071 horses, mules, and asses, for food, yielding a net weight of 15,601,630 kilogrammes of meat (34,323,586 lbs.) The net weight of meat he calculates at 418 lbs. for horses and mules, and about 110 lbs. for asses, not including the offal, liver, heart, tongue, brains, &c., which are sold like those

of oxen. In his aggregate estimate he takes the average weight, including offal, at 440 lbs. At the beginning of 1873 there were in Paris more than forty butchers' shops for the sale of horse-flesh, which was sold at half the price of meat from cattle. In the departments, as in Paris, the consumption of horse-flesh for food has made extensive progress; but it is impossible to obtain any accurate statistics of the horses killed and the number of butchers' shops devoted to its sale. It may, however, be stated that M. Vincent Giraud, of Beaucaire, has established a large factory for making polonies or sausages of horse-flesh, and for which he slaughters annually 400 horses. At Paris preserved horse-flesh is made, which, it is said, will bear a fair comparison with preserved beef.

M. Decroix is a thorough enthusiast on this subject, and has endeavoured to combat every objection urged. For instance, he says that since 1860, when he first became a confirmed hippophagist, he has endeavoured to answer the argument, that one may purchase horses which have died, or been diseased and afflicted with farcy or glanders. Although the meat is invariably legally examined before it is delivered for sale, some unscrupulous and unprincipled butchers in the country may prepare for sale diseased animals. To satisfy himself on these points he has made it a practice to eat the cooked flesh of horses killed in his service which had glanders or farcy, and, whether thoroughly or partially cooked, he found no evil results to his health. He has even gone further than this in his inquisitorial experiments as to whether the flesh of animals which have died was unwholesome. From 1861 to 1871 he has eaten the flesh cooked of all animals that have died within his reach, no matter from what disease. Desirous of ascertaining whether the flesh of cattle, sheep, and calves seized by the inspectors of meat was really unwholesome, for six months he obtained from M. Chevreul, director of the Jardin des Plantes, parts of the flesh thus seized and given to the beasts of the menagerie. Several times a week during this period he eat of this flesh without any inconvenience to his health, except certain timid apprehensions and the natural repugnance resulting from prejudice. After a personal experience of ten years, and a number of observations collected from others, he affirms that one may

eat with impunity the flesh cooked (not putrid) of any of the domesticated animals, no matter what they have died of—glanders, typhus, hydrophobia, &c.

This statement will, doubtless, meet with more opposition than M. Decroix's advocacy of the wholesomeness of horse-flesh in a healthy state properly slaughtered. I have no wish to make converts in this line; it is, however, but right that he should be allowed to speak for himself, and he publicly and openly challenges criticism. Instead of the flesh of animals which have died naturally having a more repugnant appearance, or a particular flavour, he states that he has placed the two kinds side by side in the same stewpan and with the same sauce, and in serving them to different persons, many of them connoisseurs, the meat of the animals which have died has invariably been found superior to that of meat from the slaughter-houses. If the flesh of animals which have died or were diseased is unwholesome, he, and those to whom he has given it, would have been victims long since.

The horse is as strictly an herbivorous animal as the ox, and, according to all who have tasted it, his flesh is nearly as palatable as that of the latter. Indeed, its most nearly allied relatives in nature, the wild asses of Asia and the quagga of Africa, are hunted on account of their flesh, which is thought to be one of the greatest dainties. Many tons of good animal food are allowed to go to waste during the year in every community on account of our prejudice or ignorance regarding the fitness of this animal for food, which might otherwise help to supply this deficiency we deplore. Every horse, as soon as disabled by age or accident from service in his recent capacity, could be easily fatted and slaughtered, and thus add greatly to his present value and the productiveness of the land.

In 1841 horse-flesh was openly adopted at Ochsenhausen and Wurtemberg, at both of which places it continues to be publicly sold, under the surveillance of the police, and five or six horses are weekly brought to market. A large quantity is also sold at the Lake of Constance. In 1842 a banquet, at which 150 persons assisted, inaugurated its public use at Königsbaden, near Stuttgardt. In 1846 the police of Baden authorised its public sale, and Schaffhausen followed the example. In 1857 Weimar and Detmold

witnessed public banquets of the hippophagists, which went off with *éclat;* in Karlsbad and its environs the new beef came into general use, and at Zittau 200 horses are eaten annually. The innovation gained ground rapidly, and the public sale of horse-flesh is now general in Austria, Bohemia, Saxony, Hanover, Switzerland, and Belgium. In Vienna, in 1853, there was a riot to prevent one of these horse-banquets; yet in 1854 such progress had been made in public opinion that thirty-two thousand pounds weight were sold in a fortnight, and now at least ten thousand of the inhabitants are hippophagists. These facts are very striking. When we consider, on the one hand, how strong is prejudice, and, on the other, how unreasoning the stomach, we must admit that horse-flesh could only gain acceptance in virtue of its positive excellence.

In Great Britain it is generally admitted that the flesh of the horse is excellent food at any age between three and seven years, but that at that period he is too valuable for work to be slaughtered for butchers' meat; that after seven years of age the beef will become more and more hard and unsavoury, and will therefore only fetch the price of second or third rate meat; that the supply from that source will be confined to the very old and broken-down and diseased horses that are past any kind of work, and which are unfit for human food; and therefore that the use of horse-flesh for human food can never prevail in England, let the price of meat be what it may.

At a banquet of horse-flesh given at Lyons, attended by a considerable number of commercial and manufacturing notabilities, advocates, medical men, &c., the guests expressed great satisfaction at the dishes prepared. M. Quivogne, one of the organisers of the entertainment, in giving a toast in favour of the introduction of horse-flesh for general consumption, said that the meat which had been served to the company was that of an animal five years old, slaughtered on account of a fracture which had rendered the horse unfit for further service. In answer to an objection made that horse-flesh would be dearer than beef or mutton, he stated that 600,000 horses, from seven to eight years old, might every year be killed for food, without any prejudice either to commerce, agriculture, or the army. It was also, he said, a question of humanity, for horses

eight or ten years old, becoming often unfit for service, were sold to persons who ill-fed and ill-treated them, whereas by being fattened and sold for food they would produce a profit and give wholesome nourishment to the poorer classes. Dr. Chapot, having remarked that the objection against horse-flesh was mainly caused by a fear of the effect of the dangerous maladies to which that animal was subjected, M. Quivogne replied that no alarm need be felt on that score, if, as is the case at the horse slaughter-houses in Vienna, Berlin, and Zurich, a veterinary surgeon were placed as inspector.

Mr. Engstrom, British Consul at Gothenburg, in one of his reports states that the price of ox-beef and other meat having advanced so much, had led of late to the use of horse-flesh among the poorer classes, at a cost of about 1½*d.* to 2*d.* per pound.

In the last seventeen years nearly 30,000 horses have been killed, and the flesh used as food, in Berlin. In 1853 there were five slaughter-houses, in which 150 horses were sold; in 1858, 686 were sold. The horses slaughtered for the purpose of food, in 1860, were 613; in 1861, 700; in 1862 an impetus seems to have been given to the sale of horse-flesh, 1042 horses having been sold for this purpose; in 1863 the number had increased to 1742, and in 1865 to 2240. The meat is perfectly wholesome and very tolerably palatable, resembling rather coarse beef. Grand dinners were given by a society interested in its introduction, at which horse-flesh alone was produced, prepared in various ways. Old cab-horses, wall-eyed and broken-kneed, are found to be delicious eating, when treated by a really artistic hand. Within the last three years the average of horses eaten has been about 4000 per annum; and now there are nineteen butcheries devoted to this slaughter, which is carried on under strict police supervision and regulations. The flesh is sold at about 2½*d.* per pound.

What can be done with dead Dogs?—The rapid increase and expense of dogs is endeavoured to be kept in due bounds in many countries by a tax on them. In England and Scotland this tax brought in for the year ending March 1872 close upon 280,000*l.*, which shows that there were 1,400,000. In Ireland the duty is only 2*s.*, against 5*s.* in Great Britain, but duty is paid on upwards of 271,000 dogs.

There are 120 packs of hounds kept, say of 50 couple each, which consume the carcasses of about 6000 horses yearly.

In the United States it is estimated that there are 10,000,000 dogs, they have become a great nuisance in worrying sheep; and if one-half were destroyed they would yield a return of a quarter of a million sterling by their skins, their carcasses chopped up for feeding poultry, and the refuse for manure. Some 6000 or 8000 dogs, mostly miserable mangy-looking animals, are impounded in New York annually, the carcasses taken to the offal boats, which convey them to Barren Island, where every part is turned to some useful account. The fat is rendered out, the skins sold to glovers, and of the bones and flesh an excellent compost for fertilising land is made. In some years upwards of 18,000 pariah dogs are killed in Calcutta. Many worthless dogs and cats might be killed and skinned to advantage. The skins of the biggest mastiffs are fit to be tanned for boots and shoes or thick riding-gloves; those of smaller dogs can be dressed white for gloves; and so of cats. Rid the world of many of these nuisances, and put their hides and bones to a better use than many of them would otherwise attain. In the city of Berlin, notwithstanding a heavy tax of 9*s.* and the expense of muzzles, the canine race increases rapidly, and numbers from 25,000 to 30,000 head. Some 3000 are employed in drawing carts. In Paris the tax on dogs has led to the destruction of a great number, principally by drowning them in the Seine. A number of persons have engaged in the occupation of getting out the dead bodies and boiling them down, in order to extract the fat, which is employed in the preparation of kid gloves, especially of straw-coloured ones. Of this fat about 2,000,000 lbs. are obtained. The glove-trade in Paris reaches in value nearly three-quarters of a million sterling. The carcasses of the dogs are worth from 7*d.* to 8*d.* each, the skin fetching 2*d.* to 3*d.*; the fat, boiled down, 5*d.* a pound; and the bones from ½*d.* to 1*d.*, according to weight. Three men were lately arrested in Paris and placed in charge of the police for manufacturing and selling *saucissons* of the most disgusting composition. It seems that they were composed of the flesh of dogs, cats, and other animals, mostly in a state of decomposition when used, collected by the "chiffonniers" in the streets of Paris. Had

these carcasses been sound, according to M. Decroix's opinions, they would have been wholesome. I have no doubt that the domestic cat furnishes large quantities of skins to the furrier, for much of his cheap furs.

In the silk manufacture there is a considerable waste, of from 30 to 33 per cent., in the various preliminary processes, which is only worth about one-tenth of the value of the raw silk, but this inferior product (frison) may by care and attention be considerably reduced, and the short waste is extensively utilised. The re-working up of old silk pieces, however, has not yet attained to any commercial importance, but, when we find old woollen and cotton rags so extensively re-worked, it is not at all improbable that the higher-priced and less-worn material silk, may be, ere long, re-converted by chemical and manufacturing appliances. The attention of the French Jury was drawn to this fact at the Paris Exhibition in 1867, and in the Jury Reports mention is made of the process of Mr. Hadwin, of Keybrood, near Halifax. It was remarked that while it is found difficult to obtain the waste raw material of silk, such as spoiled cocoons, knubs and husks, &c., at 7 or 8 francs the kilogramme (and which lose 26 to 30 per cent. in cleaning and preparing), old dyed silk fabrics and waste sewing-silk have been procurable for many years at something like half a franc to a franc the kilogramme. Luigi Lanzani and Brothers, of Milan, showed at the Dublin Exhibition of 1865, silk waste carded by hand and power, and what progress had been made in this utilisation in a very few years. The short fibres have little intrinsic value, but when carded with intelligence and accuracy, and spun very equally, serve, either alone or mixed with other silk, wool, or cotton, for the manufacture of goods of such beauty as to appear entirely made of silk. Silk carding in Milan is carried on by ten or twelve manufacturers, who employ upwards of 2000 men, women, and children. The total annual production may be taken at about 200 tons.

Waste Hair of various kinds, and its uses.—There is much hair of different sorts now utilised that was formerly permitted to be wasted. Cow-hair is in this country chiefly used by plasterers for mixing with mortar to make it adhere to walls. It has lately been formed into a kind of waterproof bituminous felt, to line damp walls, to place

between partitions, to prevent draught or deaden sound, for roofing, for sheathing ships' bottoms, and for clothing boilers and pipes of steam-engines.

In Sicily it is used for stuffing sofas and chair-cushions, the price locally being about 4*l.* per cwt. Carpets of cow-hair are common in some parts of Germany, selling at about 10 Prussian dollars each. Cow-hair socks are made by the peasantry in the interior of Norway, and in England bath flesh-gloves are made of cow-hair. Cow-hair rope is used in paper-manufactories, and occasionally for other purposes. The supply of cow-hair is principally obtained at home, but about 20,000 cwt. is imported, chiefly from Germany and France, worth about 5*l.* the cwt. This is probably cow-tail hair, which is used for stuffing furniture in the same way as short horse-hair. Wet cow-hair is sold at tanneries for about 2*s.* 6*d.* the bushel, and is afterwards dried and the lime beaten out. Cow-hair is sold here in packs of 240 lbs.

The trade in wool, one of the bounteous coverings of domestic animals, is well known to all, from its enormous quantity and value, and the importance attendant on the rearing of sheep here and in many foreign countries. But the commerce in the hair of other live stock and domestic animals of a minor character is less understood and appreciated, because the aggregate is not so large and the collective details are not often accessible. And yet the commerce in hair forms no mean item of our trade, regarding merely the collective imports, exclusive of what may be obtained at home. The total value of the imports of goats'-hair, pigs'-hair, horse and cow-hair, camels'-hair, and manufactures, is nearly 2,000,000*l.*, of which goats'-hair and bristles contribute the largest amount. Of alpaca wool, or hair, we imported to the value of over 513,000*l.* in 1872, of goats'-wool or mohair from 757,000*l.* to 1,000,000*l.* in value the last two years, and of pigs'-hair or bristles to the value of 516,000*l.* in 1872.

The hair of the common goat, an animal largely reared in some countries, is now much used to mix with the yarns of low-priced carpetings. Several hundred tons are annually imported from Ireland for this purpose. Tents and baling-cloths are made of goats'-hair in the East. Of camels'-hair

we have lately begun to import large quantities, but for what specific purpose, whether for shawl-making or artists' pencils, I cannot say.

Machinery lately perfected in England spins and weaves from the hair of cats, and especially of rabbits, either by itself or with a slight admixture of silk, a sort of velvet tissue, distinguishable from silk, but not inferior in fineness and beauty. It may be woven with wool or cotton. The shorter hairs, which are incapable of being woven, are readily purchased by felt-hat makers. It is rather remarkable that this use of the hair has not been thought of before, considering how many hundred million rabbits are annually destroyed.

The domestic rabbit, native of Spain, where it no longer exists, has been introduced and multiplied largely in France, Belgium, Great Britain, Australia, and other countries. About 10 millions are killed annually in Belgium, half of which are eaten in the country, and the other half shipped to England, skinned. In France about 60 millions are killed annually, the skins fetching 4*d.* apiece. Of these the larger portion go to the fur-clippers for hat manufacture. Some millions, however, are converted into furs, being utilised according to their different qualities and shades, and dyed, lustred, cut or plucked, &c. More than sixty different transformations are given to rabbit skins, and all at low prices. They are made to imitate the most costly furs, and in all cases retain their principal hygienic qualities.

The wool or fur obtained from the skins of hares and rabbits is prepared almost exclusively in France, chiefly at Paris, and is exported to all countries for hat-making and felting purposes. France furnishes the greater part of the rabbit-skins, and Russia the hare-skins. Frankfort carries on the largest trade in the preparation of the fur of the hares of Russia and Germany. Great Britain imports no rabbit-skins or rabbit wool; it uses up about a third of the number of British rabbit and hare-skins, and the other two-thirds are cut up in Frankfort, Belgium, and France. The wool or fur for hat-making now represents a considerable industry, which has only, however, risen into importance since the French law of 1847 removed the prohibitory duties on its export.

Besides the 60 millions of rabbit-skins collected in France, 30 millions are imported from other countries, representing about 6 million pounds of wool or fur (the average being 6 lbs. from 100 skins), and a value of about 1,100,000*l.* when prepared. The half of this is shipped to foreign countries—to North and South America, Italy, Germany, and Spain. It was only at the Paris Exhibition of 1867 that this raw material (now so extensively employed) was shown for the first time by any country. The wool or fur demands a series of complicated manipulations before it is fit for working into hats. The first and most dangerous operation is that termed "secretage," which is done by the aid of a solution of mercury in nitric acid, laid on the skin before stoving it, in order to crisp the hair or wool, and render it suitable for felting. Paris has about fifty of these fur-clipperies, more or less important, they nearly all work with machines, and for the most part employ steam power.

The skin, after being softened and stretched, is split, which removes the long hairs and wool. This is employed for stuffing beds in the country.

In the hare-skins, they are first scraped, and the long hairs clipped with scissors. The wool or hair is the reverse of that of the rabbit, the inner part being fine, and the ends or tips hairy. It passes through the processes of secretage and stoving, and then the fur is cut and sorted into qualities—first, the pure fur from the back of the animal; the good extra, from back and sides; the short-good, from poor weak skins; the medium, from the skin and belly; and that from the belly alone. The wool or fur has averaged in price the last twenty years, 1st quality, 14 francs to 25 francs per kilogramme; 2nd quality, 8 francs to 17 francs per kilogramme; 3rd quality, 3 francs to 10 francs per kilogramme.

The fur which has not been treated with mercury is termed "veule" or weak. The fur is turned out pale when it has been stoved only a short time; it becomes less yellow if left in longer.

The rapidity of work of the cutting-machine produces a fine hair or down, called dust, which, when blown, is worked up in the manufacture of low-priced hats. The operation of blowing has for its object to pass the fur through a

blowing ventilator, where it attains a considerable volume in the course of cleaning. The skin, after the hair has been removed, is cut into strips by a machine, and passing under the name of vermicelli is sold to glue-makers and to velvet paper-hanging makers.

Human hair is remarkable for being the only recognised marketable article produced on the bodies of our race. It is chiefly imported from France, the north of Germany, and Italy; small quantities are occasionally received from Bohemia, Austria, and Belgium. Great Britain also furnishes a small quantity, and even India and China have at various times contributed to the supply; but the bulk of hair used in this country is the growth of France, Germany, and Italy. From France the finest and softest hair is received, from Germany the light and flaxen colours, and from Italy the long dark hair. The hair from India and China has hitherto been scarcely marketable, as the texture is too coarse for use in this country.

The only purposes for which human hair is used here are for chignons and curls, the various branches of tress and wig-making, and small ornaments. Ladies' muffs made of human hair were, however, shown for some years in the Animal Products Collection, when at the South Kensington Museum. A rope or cable made of human hair (which is the strongest fibre known) was shown in the Japanese Court at the London Exhibition of 1862.

In the Jury Reports of the last Paris Exhibition it is stated officially that Paris forms the chief and most important centre of the commerce in human hair, and it is estimated that there is annually sold about 140,000 lbs., of which 80,000 lbs. is indigenous produce, and the remainder imported from Italy, Belgium, and other countries. There is also obtained about 16,000 lbs. more gathered from waste hair. This waste, called "combings," cleaned and straightened, is worth a certain price, serving to repair ordinary chignons. The United States, England, and Russia, purchase about 60,000 lbs. of this hair. France employs about 50,000 lbs. in the manufacture of false hair for ladies, and about 26,000 lbs. is thus used up in other countries. The hair of the western departments of France is the most esteemed, and the large communities of sisterhoods supply commerce with their finest tresses. An enthusiast lately

endeavoured to stimulate the employment of human hair for new manufactures.

At the Meeting of the British Association for the Advancement of Science at Manchester, Mr. William Danson offered a few observations on the manufacture of human hair, as an article of consumption and general use, and submitted for inspection some useful specimens of articles made from human hair, of a very massive and heavy texture, like pilot-cloth, or that used for travelling or mountain wear. It is, however, capable of being spun into fine goods, like alpaca, which is but of comparatively recent use. Truth goes farther than fiction. "My sister," he writes, "conceived the idea, and caused the collection of about 3500 lbs. of human hair, in a few months, in Liverpool, by one female, who was merely assisted by her husband and son in carrying it out, receiving 1*l.* to 2*l.* per week. We had two shawls made from it—cotton warp—(exhibited to the Section). It is extremely warm and durable clothing; and with care and attention any quantity of the stuff can be obtained. It would appear fabulous to say that 100,000 bales might be obtained from Egypt, and 100,000 from Asia—perhaps 500,000 or a million bales annually, from all parts of the world, even within twenty-one years, and of all sorts, both long and short, all of which is at present wasted, and not enumerated in the articles of commerce or of general consumption. I am authorised to state that this hair has been in the possession of Messrs. R. W. Ronald and Son, of Liverpool, for some years, who will forward 100 lb. weight to any applicant on receipt of a post-office order for 2*l.* 15*s.* (The items making up this sum, commission, &c., are enumerated.) The article is as collected; and heavy foreign sheep's wool, in dirt and grease, being 6*d.* to 14*d.* per lb., shows its cheapness for consumption generally. The Manchester goods are exchanged for long hair in Germany, which is sold in London at 44*l.* per ton; but the very shortest is applicable for cloth, and 10*d.* to 1*s.* per lb. is a safe price for imports. These 3500 lbs. are in seven bales, insured in the Manchester Fire Office for 200*l.* The manufactured goods may be shown at the International Exhibition in 1862; and if hair were collected in factories, the value could be quarterly divided, and added to

the Savings-bank deposit. I would suggest that specimens of these hair-manufactures should be placed in every museum in the kingdom, and trust that the Smithsonian Institution of America will give the question their ablest support. Is not the long hair of the Chinese mixed with silk and worked up by the common people?"

I may add to the foregoing remarks, that human hair is rather extensively used by savage nations, plaited into cords, for decorating their shields and other purposes.

Hair is about the richest material in nitrogen that we possess, containing when dry and clean 16 per cent. (more than the best Peruvian guano); but when damp and dirty, the nitrogen will be proportionately less, perhaps not half in the state of fellmongers' refuse. From its difficulty of decomposition, however, its fertilising action is slow, unless the solubility is promoted by other agents. There is a patent for reducing it with sulphuric acid; but the farmers may probably use it best by working well in a compost of dung and urine, with a vegetable absorbent of dead leaves, tan, bark refuse, or peat earth, to retain its ammonia. The other tanners' refuse, if of animal matter, may be chopped up and treated like the hair, if hard and horny; or if soft, mixed in the yard dung-heap. The bark refuse is of little value except for working nitrogenous matters and retaining the ammonia.

Farmers who slaughter their own hogs generally allow the hair to go to waste. In the large butcheries in cities it is carefully saved for use in the arts, and forms a considerable item in the profits of the business. It would not pay, perhaps, for those who have but a few pigs to kill, to send the hair to a distant market. But still it should not be left to waste. It is a very powerful fertiliser, and, if saved and applied to the soil, either garden or field, with the waste of the scalding tubs, will be found profitable.

In the United States, pigs' bristles are used for stuffing chair seats and other upholstery; and it is possible that this kind of hair sometimes gets mixed intentionally here with other descriptions designed for mattresses, &c.

In China all sorts of hair are used as manure, and barbers' shavings are carefully appropriated for that purpose. The annual produce must be considerable in a

country where some hundred millions of heads are kept constantly shaved. Lately the Celestials have found it profitable to ship their spare hair to Europe; for, in 1872, no less than 100,000 lbs. of human hair was received at Marseilles, principally from China.

Utilisation of Blood, Bladders, Guts, &c.—There are many uses for blood: it enters into food products, in the shape of black puddings; is used for dyeing, sugar-refining, animal charcoal, albumen, and for manure.

In the practice of medicine, as in other worldly matters, certain things are in fashion for a limited time. Bleeding and mercury have had their day; cod-liver oil and chloral hydrate are already on the wane; alcohol and bullock's blood are now in vogue among the Parisians—the former for fevers and all inflammatory affections, and the latter for anæmia and pulmonary phthisis. It is said to be a curious sight in Paris to see the number of patients of both sexes, and of all ranks and ages, who flock to the slaughter-house every morning to drink of the still fuming blood of the oxen slaughtered for the table. According to M. Boussingault, of all nutritive substances the blood of animals contains the greatest quantity of iron, and it is this which gives value to the new medicine.

Albumen is now produced on a large scale at Pesth, Hungary, and in North Germany, from the blood of animals. The serum separating when blood coagulates consists chiefly of albumen. The best patent quality thus made is transparent and soluble in water, and is used for mordanting yarns and cloth. At Pesth, blood is dried in flat iron pans by exposure to air at a temperature of from 100° to 112° Fahr. From 3000 lbs. of blood about 110 lbs. of albumen are obtained, at a cost of 29 thalers; 16,200 eggs would yield the same amount of albumen, at a cost of 96 thalers. Although the cost of egg albumen is three times as great as that of blood albumen, the former is preferred for dyeing purposes, on account of its purity. The residues forming albumen of a second and third quality, darker in colour, but nearly all soluble in water, are used largely in the process of refining sugar.

In France the idea of utilising the blood of animals for food, which formerly was wasted or used only for manure,

has been carried out extensively. A M. Brocchieri treated the blood of the slaughter-houses by means which he had invented, and, uniting to flour of the best quality the albumen and fibrin which he extracted from it, he made bread and biscuits and other articles, which are easily preserved, and which can be employed to make very nutritious soups. This preparation contains, according to the inventor, one-half of the nitrogen of the blood consumed.

The preparations were intended to utilise the nutritious principles of the blood of animals killed for food, by reducing it to a concentrated and dried state for preservation during long periods. First we are shown the solid parts forming the crassamentum or clot in a dried or semi-crystalline state. These solid constituents, including the gelatin, albumen, and fibrin, are next produced, combined with small portions of flour, in the form of light dry masses like loaves, cakes, or biscuits. Then again we have large samples, inodorous, almost flavourless, which may be made the basis of highly nutritious soups. They are very uniform in composition, containing half the nitrogen of dried blood, or 44 per cent. of dried flesh, the equivalent of double the nutritive value of ordinary butchers' meat.

The evidence as to the value of the process in preserving the samples in an indecomposed state is now satisfactorily arrived at. It was understood in 1851 that the preparations had been advantageously employed in long voyages; but the evidence was not then established. However, the samples have been kept these twenty years, and have not shown any tendency to decay, thus proving that the first attempt was successful, in rendering generally available for food, and portable in form, the otherwise wasted blood of cattle.

Blood is composed almost entirely of albuminous matter, of which 51·3 per cent. is contained in the clot which forms after the blood has flowed, and 48·16 per cent. remains in a liquid state, and is called serum. The albuminous matters in the blood are composed of hematin, 24 to 36 per cent.; globulin, 12·5 per cent.; and the remainder, fibrin. The true albumen is found in the serum, which contains ·08 of it. Fibrin owes its name to the property which it

possesses of forming by coagulation a fibrous mass insoluble in water, and which approaches in its qualities the fibrin of flesh. Pure globulin is very soluble in water, but it cannot be separated from the hematin associated with it in the clot, except by chemical agents which decompose it. Hematin is near akin to albuminous matters; but it is especially distinguished by the colour, which, originally red, passes to black in drying, and by the quantity of iron which it contains. Albumen extracted from blood is, of all substances of which it is composed, that which has the most analogy with the albumen of eggs. Like the latter, it owes its power of solubility in part to the presence of basic salts of sodium.

The blood and other offal of slaughter-houses in our small towns and villages, now entirely wasted, might with a little management be turned to good account. In the large towns the blood is collected, although not very carefully, and finds its way to certain classes of manufactories, in which it is employed. Such, however, is the carelessness of the workmen employed in slaughter-houses, that even in the large towns it is with difficulty that they can be persuaded to save the blood, although its price is really considerable. It would be a matter of some interest to ascertain the annual value of the blood and offal thus lost, which is undoubtedly very large, and a great part of which might easily be saved.

To preserve blood to an indefinite period, it is coagulated by boiling, either in a common furnace-pot, or, what is preferable, by means of steam. The coagulated part is removed as it rises by means of a scoop, and dried in the air. In this state it may be reduced to powder, and transported without inconvenience to any part of the world. In this form it is a very rich manure, containing 13 to 14 per cent. of nitrogen.

The researches of Professor Way on dried blood as a manure, will place that common and much-wasted substance in a position of more favour with the agriculturist than it has hitherto obtained. From the Professor's investigations it would seem that the blood is really, when dried, more productive of ammonia and nitrogenous matter than even the flesh. The analyses of the two are thus given :—

	Blood.	Flesh.
Carbon..	54·35	54·12
Hydrogen	7·50	7·89
Nitrogen	15·76	15·67
Oxygen	22·39	22·32

In several other specimens he found that they contained as much as 13 to 14 per cent. of nitrogen, and therefore equivalent to about 17 per cent. of ammonia—a quantity nearly as great as in an average set of specimens of guano. It must be borne in mind that the blood in this case is taken dry, and that if not perfectly dry it will not only be much less valuable, but more offensive and less manageable as a manure, for one of the most certain preventatives of decay is the absence of water.

Of the value of dried blood, it may be taken to be worth 8*l.* to 9*l.* per ton if highly dried, calculating its ammonia at 6*d.* per lb. It contains less phosphate matter than guano, still it may be made a useful auxiliary and to some extent supply the place of Peruvian guano, the most valuable of all our purchased fertilisers.

The use of blood is well understood by the manure-makers, one firm of which in London consumes 2500 gallons per day. In Northamptonshire the farmers compost it with peat-ashes and charcoal-powder, about 8 bushels to 50 gallons of blood for turnips and young wheat; for turnips, 48 bushels an acre (or 16 bushels with dung); for top-dressing young wheat, 20 to 30 bushels an acre. They keep the compost a year or more, but five or six months would probably answer if turned well up once a month or oftener. About twenty years ago the quantity of blood collected from all the animals slaughtered in the metropolis was ascertained to be upwards of 800,000 gallons annually, the great bulk of which was purchased by the Blood Manure Company, Limited, and about 32.000 gallons used by sugar-refiners and for other purposes. The quantity now collected is much smaller, so much dead meat being brought to London. Fresh blood is worth about 2*d.* per gallon, or nearly 2*l.* per ton, and any farmer living near a small town might advantageously contract to take the whole of the blood at this price.

Catgut is the name applied to strings made from the dried twisted parchment covering of the intestines of the sheep. The greatest care is necessary to prepare these

strings for the violin, the harp, and similar instruments, to secure the strength necessary for the great tension required for the high notes. The finest strings are made at Naples, because the sheep, from their leanness, afford the best raw material. It is a well-ascertained fact that the membranes of lean animals are much tougher than those of animals in high condition.

The violin has four gut-strings, the guitar three; those of the harp are made of the finest catgut, some of the lower notes being of silk, lapped with fine silver-wire. We import gut strings to the value of about 2000*l.* a year.

Catgut-cord is used for a variety of purposes where strength and tension are required, as for the strings of musical instruments, for suspending clock-weights, bow-strings for archers, and for hatters' use.

The gut-strings employed by turners, grinders, and for cleaning cotton, &c., are made with the intestines of oxen, horses, and other animals. These, cleared by putrefaction of the mucous and peritoneal membranes, and treated by a solution of carbonate of potash, are cut into strips by means of a peculiar knife and spun in the same way as the musical strings.

The uses of bladder and gut for holding lard, for covering gallipots with preserves, as cases for polonies, &c., and other domestic purposes, are well known.

Insufflated or inflated guts are chiefly used for the preservation of alimentary food, as cases for Bologna sausages, polonies, black puddings, tongues, preserved meats, &c. These substances have to pass through a long series of modifications and preparations before becoming articles of use.

Besides our large home supply of bladders, we import six or seven hundred thousand a year from the continent, and the aggregate value of the bladders used in the United Kingdom is estimated at 40,000*l.* or 50,000*l.*

The goldbeaters' skins are formed by the peritoneal membrane of the lowest gut (*cæcum*) of animals. The membrane, separated from the outer gut, is dried and then put for some minutes into a weak solution of pearlash, then scraped, washed, and opened upon a frame. Another membrane, treated in the same way, is applied upon the former, the surfaces in contact being those which had been previously in contact with the muscular membrane. They at

once adhere to each other and form one body. When dried, the double membrane is moistened with a solution of alum and then covered with a coating of isinglass, to which aromatic substances have been added. When this first coating is dried, another, consisting of white of eggs, is passed upon it, and when dry it is submitted to the action of a strong press and formed into small books for use. The processes adopted by various manufacturers differ in some small degree.

Uses of waste Leather.—Among the varied waste substances which have long been unutilised and of no value is scrap leather. The quantity of hides and leather annually used in the United Kingdom, exclusive of the exports, cannot be less than 66,000 tons.

In large towns, these leather-parings and clippings are used in cementing iron cutting-tools; at other times they are worked up in the manufacture of cerrocyanide of potassium. But this application utilises only a small portion, as it is not possible to consume all this scrap-leather in the preparation of nitrogenous charcoal; hence for this purpose old shoes are chiefly used up. Agriculture can derive but a small advantage from this waste, for although the cellular tissue which supplies gelatin contains a considerable quantity of nitrogen, yet the tannic acid in the leather is injurious to plants. No extensive and remunerative application has yet been found for waste leather. In summer these clippings and leather waste are suffered to accumulate about the works, to be used up in winter for heating the warming-pipes—a barbarous method of use. It is known that leather, heated under steam at a pressure of two or three atmospheres, is dissolved without any sensible change in its chemical composition. At the temperature of 130° centigrade the animal membrane which furnishes the gelatin is changed into a kind of modified gelatin, insoluble in water, and presenting a hard and brittle substance which it has not yet been found possible to change. Treated by steam, bones present the same appearance. A temperature of 130° centigrade acts on the gelatin in the same manner as free oxygen and other bodies, which render the gelatin brittle and insoluble in water. Leather cuttings, treated with organic acids at a temperature not exceeding 80° centigrade, are completely

dissolved, and by this method the membrane yielding gelatin is not changed into an insoluble substance. A small quantity of organic acid will effect this dissolution, for 15 grammes of tartaric acid will dissolve easily 1 kilogramme of leather, or the tartaric acid of potash may be used in the proportion of 30 grammes to 1 kilogramme of leather. Small doses of acetic acid act more leisurely on the substance and are less destructive. Heated in a copper by steam at a temperature of 80°, the substance dissolves in three or four hours. A small proportion of soda may be added.

After cooling, the mass remains a long time soft and elastic, and to give it some consistence it is washed in warm water; insoluble in water, it loses all trace of the acid. If the mass is required to be soft and ductile, 10 per cent. of acid is used instead of 4 per cent., and instead of water an equal weight of glycerine to that of the leather to be acted upon is used. This substance can be employed for printers' inking-rollers. It mixes well with indiarubber, and may be advantageously and economically used for the upper leathers of shoes or goloshes. For this purpose the leather-cuttings may be dissolved at a low heat with 7 per cent. of acetic acid, 15 parts of rape or other oil, 15 parts of glycerine, and 6 of water. After cooling it can easily, by means of hot iron cylinders, be mixed with caoutchouc. The caoutchouc, after cutting, has to be plunged for some hours in one-fourth its weight of bisulphate of carbon. Thus treated the caoutchouc combines readily with the dissolved leather, and the resulting mass is susceptible of many useful applications. The quantity of caoutchouc that may be added is quite arbitrary. The proportion best suited for all practical purposes is a mixture of about 100 parts of leather to 12 or 15 of caoutchouc. This mixture is not suggested as a substitute for caoutchouc, but by reason of its low price and impermeability it is susceptible of being applied to many useful purposes.

In treating the waste leather, that from sheep-skin does not require cutting up; but the upper leathers of boots and shoes must be shred into small pieces, and the sole leather boiled in a solution of tartaric acid. The mass thus treated acquires much solidity after several days, and calenders or printing rollers for cotton fabrics may be made with it.

Although it is asserted that tannic acid may be precipitated by strong mineral acids and a great number of salts, there are only a few bodies which are capable of thoroughly separating the tannic acid from the animal skin, that the gelatin may be eliminated and economically collected so as to be of commercial value. These substances, besides being few, are high in price and uncertain in their action. The effect of strong alkalies on the leather is, however, effective and simple. They destroy the tannic acid and transform it into humic acid, and effect an entire change in the nature of the gelatin. A weak solution of soda may be advantageously employed in preparing a commercial product from the gelatin of leather. The leather is first dissolved in tartaric acid, and this is removed by washing, and the mass is boiled in a solution of soda, in the proportion of 30 grammes to the litre of water. This is then rolled out into thin sheets, and exposed to the atmosphere to destroy the tannic acid in the alkali. After a few days it is again boiled in soda, and once more rolled to expose a new surface.

After this process has been repeated four or five times, the tannic acid is entirely separated, and with the animal membrane, which remains uncontaminated with fibrous matter, glue can be made. This method of making glue from old leather has advantages over the existing methods in use, in that the process of manufacture is much shortened, the yield is stronger, and the glue obtained will fetch a higher price.

Occasionally some new utilising method is proposed, and one or two of the more recent are worthy of passing notice.

One of these relates more especially to the waste from sheep and calfskin leather. The inventor takes about 14 lbs. of the cuttings. With this he uses 1 cwt. of cuttings of sheepskin and 56 lbs. of fibrous material, preferably wool, although hair or even hemp may be used. The mass is cleaned, torn to fine pieces by suitable machinery, then treated with alkalies to remove oil, &c., and afterwards pulped in a pulping engine. The material thus prepared is then conveyed to wire-cloth moulds, in which it is pressed into sheets, the pressure being by preference aided by a partial vacuum. The sheets are dried either by exposure to the air or upon steam-

heated plates, and are finished by being passed between hot iron rolls.

In another alleged improvement in the utilisation of leather waste, applicable, however, only to pieces of appreciable size, the fragments, instead of being disintegrated and mixed with other material, are cut by dies into squares, diamonds, triangles, &c. The dies are made to act obliquely, so as to give bevelled edges to the pieces, which are laid with these edges overlapping, and with a layer of cement between them. Heavy pressure is applied to secure perfect adhesion, and the result is a sheet of leather made up of little pieces joined together. This may be used for any suitable purpose, either as it comes from the press or as finished by receiving upon each side a sheet of very thin leather, which may of course be "split" leather, and this gives greater smoothness and finish to the surface.

Mr. John Blakey, of Lady Lane, Leeds, has patented a machine for utilising waste leather for making "lifts" or heels, at a cost of about 2*d.* per lb. The machine or apparatus is for moulding rolls or blocks of the scraps or bits of leather to the form of boot or shoe heels, comprising a mould or box in two parts; this box is placed vertically in a table or stand, the top being even with the surface. A lever is hinged on a pillar fixed upon the table, to one end of which lever is attached a rammer of the same form as the box, and in such manner as to enter into it when pressed downwards. A spring is applied to the other end of the lever, and a treadle is attached, so that the attendant can operate the same. A plug is inserted into the top of this box, which by means of a spring is held sufficiently tight therein, yet capable of being driven through the box by the rammer. The attendant places a layer of scraps of leather within this box upon the plug, and upon them a coating of cement and another layer of scraps, then by means of the treadle operates the rammer, which forces them down the box. Another layer of cement and scraps is then introduced, and the rammer used to force them forward as before, and so on until the box is filled, when it is opened, and the roll or block of scraps thus placed and cemented together is removed thence and placed in the press to be operated on.

Messrs. Joseph Hall and Co., of West Street, Leeds, are also patentees of waste-leather utilising machines for making "lifts," a term in the shoe-trade for the leather which goes towards the making up the heel of a boot.

Another apparatus has lately been devised in England for use in the process of making washers, insoles, and heels for shoes, from scraps of leather, by reducing the leather to shreds, and before the scraps can be torn they must be formed and so kept in a compact mass, while being acted upon by the tearing teeth. The machine has a feeding-box, a follower or piston, and a set of revolving tearing teeth, at intervals in the direction of their axis of revolution, the combination of parts being such that the teeth tear over the whole exposed surface of the material acted upon. A set of revolving clearers act to clear out the tearing teeth, and a contrivance is used for throwing streams of water upon the teeth.

Mr. E. S. Hidden, of Midden, New York, took out a patent in June 1871 for disintegrating scrap leather, and conducts the manufacture on a large scale. The shredded material has been successfully applied for journal boxes, and is also employed as a substitute for curled hair in mattresses and cushions.

Whether either of these plans for making use of a waste product will practically secure the end desired can only be ascertained in the course of time; but they belong to a class of inventions which has frequently proved most remunerative, viz., that of making small improvements intimately connected in one way or another with great industries.

We know that the scraps and trimmings that fall from the shoemaker's bench are collected and sold, and that these finally reach manufacturers of leather board—largely used at Boston, United States—which, in cheap shoes, is used to give thickness to an inner sole, that has but little real leather in it, and for shanking and counters. But what becomes of worn-out boots and shoes, and all other articles made of leather which have been cast aside as of no further use? It was in pursuit of this inquiry that we learned that worn-out hose and belting are cut up into soles for boots, and that the "uppers" of boots and shoes, whereof the soles have become demoralised, are carefully separated, subjected to various processes, which

make them take on the semblance of newness, and then trimmed round, leaving them sufficiently large to make the "uppers" for smaller feet than they covered before. Thousands of such "uppers" are sold annually, and it is not safe for those who buy their boots without regard to the standing of the dealers to assume that their understandings are new throughout.

A steam-engine is employed at Abington, Massachusetts, in grinding up the chips and shavings of leather, which are cut off by shoe and boot-makers, and which have heretofore been burnt or thrown away. These are ground to a powder, resembling coarse snuff, and this powder is then mixed with certain gums and other substances so thoroughly that the whole mass becomes a kind of melted leather. In a short time this dries a little, and is rolled out to the desired thickness, perhaps one-twelfth of an inch: it is now quite solid, and is said to be entirely waterproof.

The utilisation of leather scraps is a subject of much importance, even to the town of Leicester, where from five to six tons of leather scraps are made weekly, which are mostly burnt, or at best employed as manure. There is one use, however, to which they are applied largely already alluded to—the manufacture of "shoddy leather" —a manufacture from refuse scraps, which are reduced to a pulp by grinding and maceration, and converted into solid "sides" of leather by pressure. The article thus produced is used mainly for inner soles.

There is an American story told of a man who, upon being informed that a disciple of St. Crispin kept a "pancake shop," found himself at fault when he politely inquired for Mr. Jones, the pastry baker. Those unlearned in the singular nomenclature which attaches to every branch of the shoe business may be informed that "pancake" is a sort of nickname for a combination of paste and leather, which is used in the manufacture of heels for some qualities—not the best—of shoes. The more polite and proper term is "pasted stock." It consists of a number of layers of very thin leather, which are the odds and ends cut off by the tanners from whole sides; these are made quite compact by means of a layer of paste between each layer of leather, until the whole is about an inch thick,

when it is placed between two iron rollers, and subjected to a tight squeeze, after which it is dried, and is then ready for use. The pancake, when finished, is in blocks or cakes, perhaps 4 inches wide by 12 long, and half an inch in thickness, and looks like a cross between a sheet of gingerbread and a huge cake of tobacco. Hence, I presume, its name.

There is a great "pasted stock" manufactory in the large shoemaking town of Lynn, in America, which employs between forty and fifty men and girls, who are occupied in cutting out the leather and pasting it together. The extent of the business may be inferred from the fact that they use up four barrels of flour into paste every week, and consume I don't know how many tons of scrap leather, which is made into pancakes, inner soles, stiffenings, and the like. They have a powerful steam-engine, which runs a rolling-machine, and a large boiler furnishes steam for making paste and heat for the drying-room. In this room the blocks or cakes before spoken of are placed, and all the moisture taken from them. This firm does a large business, and their method is interesting to those who have any curiosity to know to what an extent economy is practised in the use of old material for the remanufacture of boots and shoes.

The distinction between the shoe mender and the translator is in the mode in which they follow their calling. The shoemaker or cobbler seldom works till the shoe is brought to him by the wearer, while the translator makes it his business to purchase old shoes, or get them as he best can, mend them, and then seek a customer at a price that pays him for his trouble and expense, and gives him a living profit. The clobberer is nothing more than a cheat, or one who clobbers up a defect, instead of getting rid of it.

Messrs. J. W. Gale and W. W. Boyden, Bristol, took out a patent in December 1871 for utilising waste leather. The leather cuttings and scraps are torn into shreds or ground into dust, then subjected to a solution of acid, and heated to make the mass glutinous, washed in alkaline water and pure water, and again subjected to heat, adding glue or size prepared in acids or coal tar. Thus heated the material is rolled or pressed into sheets, or the shreds or

dust are mixed with water and glue, prepared with acid or coal tar. Before being dried it may be used with paper pulp, also in making india-rubber, gutta-percha, and parkesine, but particularly for the soles of boots and shoes and floor cloths. It can be vulcanised.

Old leather has been converted into paper, of which there are samples in the Animal Products Collection in the Bethnal Green branch of the South Kensington Museum.

The working-up of leather scraps into an artificial product resembling the original material has been very frequently attempted, and to some extent carried into practice. It is almost superfluous to say anything in regard to the great value of a cheap and good process for the utilisation of leather waste. This waste represents thousands of pounds annually. A process that could reproduce a texture of these cuttings, only one-half as good as the original leather, would be one of national importance, and would at once establish a new industry. Here is a method lately proposed by a Danish inventor, one Mr. Thamsen, of Copenhagen. He takes leather waste, cuttings, shavings, or other small bits of leather, either new or old, and reduces it to a kind of fibrous pulp by hand-labour, or by a machine or mill (either by grinding, pounding, cutting, rasping, carding, or grating); if old waste is used, it should first be cleaned thoroughly. This matter or pulp is then kneaded with india-rubber, which is rendered fluid or dissolved in oils or spirits, and treated with ammonia. Here we dissolve the india-rubber in oil of turpentine. To effect this, the india-rubber is cut into pieces and mixed with the turpentine, after which he lets it remain quiet in a closed vessel until it is dissolved. When the india-rubber is dissolved, he adds ammonia of a strength of 30 per cent. in the proportion of about equal parts by weight of ammonia to the india-rubber contained in the solution; when the mass has become of a grayish-white colour, it is ready to be mixed with the pulp.

Mr. P. J. Oerting, of Pensacola, Florida, has introduced this Danish process into America, and he thus describes his patented plan. It is said to make uniformly an artificial leather, even superior to ordinary tanned sole leather. Examination of these specimens reveals the following

facts: It is much harder than ordinary leather, and does not yield to hammering or compression nearly as much. It is very flexible and elastic. Thin shavings of it possess as great tensile strength as shavings of equal thickness of common oak-tanned leather. It is nearly, if not quite, impervious to water. It cuts smoothly and easily in working. With regard to its durability under wear, we have no doubt it would wear longer than sole, provided it does not decompose by exposure. We have no means of determining this latter point, but we are assured that it does not decompose or change under the ordinary circumstances of wear to which leather is exposed in its various uses.

It is claimed that the leather thus made is equally good for soles or belting; and the tests as to its tensile strength, flexibility, and elasticity, certainly go to corroborate the claim.

A really practical method for making artificial leather of scraps has long been sought; but heretofore nothing has been obtained that combined all the essential properties of good leather.

The ingredients employed and their proportions are as follows:—For first quality, 1 lb. of caoutchouc for each $3\frac{1}{4}$ lbs. of leather pulp. For other qualities, the proportion of leather pulp is increased variously up to 6 lb. for 1 lb. of caoutchouc. The caoutchouc is dissolved in benzine or other solvents, and, when sufficiently dissolved, aqua ammonia is added in the same proportion as that of the rubber, and the mass is thoroughly stirred until it assumes a greyish-white colour. The leather pulp is then added, and the whole is kneaded into a plastic homogeneous dough of uniform consistency, which can be pressed or moulded into any required form, or rolled into sheets, as may be required.

The ammonia is claimed to act upon the animal glue in the cuttings, restoring to it that vitality, which it had lost to a great degree in the process of tanning.

The following are some of the properties and uses of this remarkable substance, as claimed by Mr. Oerting:—Its waterproof quality makes it especially valuable for pump-leather, as well for cold as hot water, and also for harness, as even a continued exposure to all kinds of

weather has no effect on it, occasioning neither rot nor crack. It can be made endless, or of any length, width, and thickness required, and of perfect uniformity as to wear, which is generally well known to be impossible with leather belts made of shorter pieces of differcnt hides, and of unequal wearing capacity. It will stand any amount of heat and friction, as well as the most intense cold; will stretch less than any other belting, and can be changed from one pulley to another with ease and rapidity. It is very strong and substantial in the edge, and will stand a great amount of ill-use without suffering any injury, and through its combined properties will supply a desidcratum much needed. By suitable machinery for moulding or forming the material in its doughy state into hose, fire-buckets, &c., for which purpose it is especially adapted on account of its inflexibility, impenetrability by water, and its capacity to withstand any amount of hardship, as well as extreme heat or cold, it will certainly make the best, as also the cheapest material yet produced for such purposes.

By a different mixturc and proportion of the ingredients, a matting for covering floors is made, which, on account of its cheapness, its waterproof properties, and its capacity to keep rooms protected from cold and dampness, makes, it is claimed, an unequalled article for covering offices, passage-ways of public buildings, &c., as it will withstand an immense amount of wear, and can very easily be cleaned. It is stated by the producer that the cost of the materials employed in its manufacture amounts to about $11\frac{1}{7}$, $13\frac{1}{2}$, $16\frac{1}{5}$, and 19 cents respectively per lb. for the different qualities, besides from 12 to 14 ounces of scrap leather, which prices, calculated after the prcsent rates of the raw ingredients, would be reduced at least 15 per cent. by a direct importation in larger quantities.

Under a process of Mr. F. J. Bugg, soft leather cuttings are mixed with a solution of gelatin or size to make a paste. This is spread upon a sheet of metal slightly oiled or covercd with a thin cloth to prevent adhesion. A covering of curriers' shavings is then laid over the shect. The whole is subjected to hydraulic or other heavy pressure for a few hours. The pressed leather is then hung up to dry, to fit it for the market.

Mr. Johnson, of London, has obtained a patent for preparing old leather scraps to render them fit to be made into glue. The leather is first chopped into small pieces and thoroughly washed, then placed in vats, where it is taken out after a few hours, and subjected to pressure, and again immersed in a stronger alkaline solution some hours, which process removes all the tannic acid. It is now taken out and washed well with water, and submitted to a steep of a very weak sulphuric-acid for twenty-four hours, to remove all colouring matter. This being accomplished, it is again submitted to a weak alkaline solution of carbonate of soda, then washed in water, and is fit to be made into glue by the common process.

Under the name of artificial parchment, Captain J. H. Brown, R.N., started a process some years ago at Romsey, for making parchment direct, by treating the parings of raw hides with alkaline solutions, and succeeded in producing a very capital substitute for parchment, satisfying all the conditions, even to appearance, specifically belonging to the original article; but the chemical discovery, by which waterproof or unsized paper is transformed into a vegetable parchment, nearly as strong as animal parchment, has superseded the utility of this invention for many purposes.

Throwing an old shoe after a newly-married couple will have a new application hereafter. It will be not only an emblem of good luck, but a substantial present. It should be publicly known that it is sheer waste to pitch old boots and shoes into the streets as useless and of no value. They should be reserved for nobler uses, and made to contribute to the delectation of the palate. That this can be done was illustrated by a chemist lately at a meeting of the New York Liberal Club. He exhibited for the information and examination of the members a pudding, or rather a jelly, made out of an old boot. The fellow of the boot of which the jelly was made stood alongside, and proved to be a veritable old fellow, who bore the marks and scars of a long and useful life. Subsequently the learned gentleman explained the process of the manufacture, which I reproduce as a matter of interest to housekeepers generally. "Skins," said the professor, "are nothing else but gelatin, but after they are exposed

to the action of tanning they become leather, and in that condition insoluble. If, however, the leather of a boot is put into a close vessel with lime and water, where it can be subjected to a pressure from the steam of about two atmospheres, the tannin unites with the lime, and the leather is restored back into its original gelatin; and can then be cast into a mould, and served up at table." The jelly was of the colour of molasses, and tremulous, and looked like incipient glue. Several tasted it, and spittoons were at once demanded. We may soon expect to see the new dish on the bill of fare of our restaurants and hotels as boot jelly. Then there will probably be regular seasons for this delicacy—seasons when it is the most fragrant, as after a hot summer for instance, or from an importation of old Southern plantation shoes, or from butchers, stablemen, &c. If the prices of old boots should be so much advanced by this new discovery as to go far toward paying for a new pair, how the boot and shoe trade will look up.

There is a considerable and unnecessary waste of useful leather, of which the leather trade justly complain, by the careless and unnecessary mode of branding cattle in South America and other countries. Surely there are other modes of distinguishing cattle than by permanently injuring their hides. There are pigments that are hard to get rid of when once applied; or the tail and head might be marked instead of the sides of the animal.

Uses of Bones and Animal Charcoal.—The trade in bones has now reached to a very large amount, not only for manufacturing purposes, but as a fertiliser for the soil. The foreign imports sometimes exceed 100,000 tons yearly, valued at 660,000*l.*, while those collected at home are computed at nearly the same amount. In 1850 we imported but 27,198 tons. In 1872 we received 97,778 tons; of these but 4056 tons were suited for manufacturing purposes, and the rest were converted to manure. Those imported average in value about 7*l.* per ton, the price having more than doubled within the last ten years. The bones obtained at home are more valued, in consequence of the gelatin they contain. Some of the shank and other bones are used for handles to knives, forks, and tooth-brushes, and for buttons, combs, &c., and the bone

waste or dust, after they are boiled and crushed, for manure. The prices in London in May, 1873, were—for bone-ash, 5*l.* 5*s.* to 6*l.* per ton, on a basis of 70 per cent. phosphates; half-inch bones and bone-dust, 24*s.* per quarter, animal charcoal, 5*l.* to 5*l.* 10*s.* per ton.

We import bones from all countries—Australia, South America, Europe, Africa, the great seats of the fisheries, and even from the battle-fields and the Pyramids of Egypt. A correspondent of the 'Times,' writing lately from Alexandria, humorously remarks:—"Fancy mutton fattened on ancient Egyptians! It's a fact—a horse chestnut is not a chestnut horse, but, by a sort of *sorites* inverted, we may arrive at the idea of a *gigot* which shall consist in great part of the dwellers in Memphis. The other day at Sakhara I saw nine camels pacing down from the mummy pits to the bank of the river, laden with nets in which were femora, tibia, and other bony bits of the human form, some 2 cwt. in each net on each side of the camel. Among the pits there were people busily engaged in searching out, sifting, and sorting the bones which almost crust the ground. On inquiry I learnt that the cargoes with which the camels were laden would be sent down to Alexandria and thence be shipped to English manure manufacturers. They make excellent manure, I am told, particularly for swedes and other turnips. The trade is brisk, and has been going on for years, and may go on for many more. It is a strange fate—to preserve one's skeleton for thousands of years in order that there may be fine Southdowns and Cheviots in a distant land! But Egypt is always a place of wonders."

The importation of bones from Sebastopol has suggested painful doubts, which will not be set at rest except by the most satisfactory explanations. It must be stated, however, that this is a trade which has been carried on in the agricultural interest for upwards of forty years. Piles of bones may be seen in Scotland, intended to enrich its fields, and imported from Russia. There exists at St. Petersburg a merchant named Stepanoff, who has dealt in these bones all his life, and exports annually to foreign countries upwards of 1000 tons.

Bones of almost all animals are now articles of commerce; whether wild or domesticated, they are made to yield parts

of their skeletons for some useful purpose, and we import the bones of the giraffe, elephant, horse, cattle, and whales.

Bone is an important agent in many manufactures, being used by potters, turners, cutlers, glue-makers, sugar-refiners, assayers, and by farmers for manure. About two million shank-bones of oxen are worked up every year in Sheffield for knife-handles, and they are also made into tooth and nail-brushes, combs, fans, bone flats for making button-moulds, and various miscellaneous articles.

In the various stages of the useful application of waste bones, we have first the shank and the cut bones, as collected and received; then carbonised bones, burnt in closed air-tight retorts for about twelve hours; then grain animal charcoal, the carbonised bones ground between grooved iron plates, used very largely as a filter to deodorise sugar in the process of sugar-refining; ivory-black, the portions of the carbonised bones which, in the process of grinding, become too fine for grain animal charcoal, and are reduced to an impalpable power for blacking-making; sulphate of ammonia, the liquor distilled over in the process of carbonising bones, afterwards saturated with sulphuric acid and evaporated to salts, used as smelling-salts and largely as a valuable manure; bone grease, extracted from the bones before the process of carbonising, used largely for the manufacture of soap.

Analogous useful products to the coal-oils have recently been extracted from bones submitted to destructive distillation. Mr. J. Shand exhibited in 1862 specimens of oil thus obtained, adapted both for lubrication and illumination. The Jury regarded the production of these marketable oils, upon a manufacturing scale, from the highly offensive and hitherto almost useless bone-tar, as of sufficient importance to merit the award of a medal.

Bones rich in phosphate of lime were first collected and used, but this source of supply was not fully adequate to the demand, the more especially as industries other than that of agriculture were competitive for bones, and could offer the inducement of better prices. Thus the sugar-refiner and the manufacturer of shoe-blacking were consumers of bones in their various departments. These, after calcination and conversion into a porous mixture of carbon, carbonate and phosphate of lime, are required in the one case

as a decolourising filtering material, and in the other as the pigment basis of the product. The spent bone-black of the first manufacturer ultimately passed through the hands of the manufacturer of "super-phosphates" into those of the farmer and thence to the soil, but chemical science has delayed this passage by the discovery of methods of recovering this "spent-black" in such a manner as to enable it to be repeatedly used in sugar-refining before it finally comes to the soil. The "bone-black" used in shoe-blacking and in some other minor articles is distributed and lost to such a degree that its phosphoric acid is irrecoverable.

Messrs. Dunod and Bougleux of Abervilliers, France, have carried out many improvements in the apparatus and processes employed in the commercial utilisation of bones, and for which they lately received the thanks of the Society for the Encouragement of National Industry of Paris.

They submitted the following samples of their products to the Society:—Coarse filtering bone-black for sugar-works; bone-black of a medium fineness for refineries; empyreumatic oil; bone tallow; impalpable bone-black for painting and blacking; a kind of black for manure; a superphosphate of lime mixed with bone-black for agricultural purposes, that is, a mixture of bone-black and bones treated with sulphuric acid; bone-dust for manure; sulphate of ammonia; white bones for the manufacture of cupels; vitrified bone for the manufacture of opal glass, of which 25 tons per annum are made.

The establishment of MM. Dunod and Bougleux treats each year about 7000 or 8000 tons of bones, or the value of about 3000 francs for each working-day; it employs 80 men in ordinary times, and as many as 120 during the most active season—that is, when the manufacture of sugar is most vigorous, and demands the greatest quantity of black. Two steam-engines, one of 25 and the other of 10 horse power, drive the machinery, consisting of a bone-crusher, mills and bolts for the black, pumps for the liquids used, and, finally, cranes for handling heavy apparatus. Nine horses are employed for transporting the material.

The bones, upon their arrival at the factory, are first sorted to separate foreign substances, particularly bits of

iron and stone, and also for the purpose of setting aside certain kinds and portions of bones for special purposes. The greater part, after being sorted, is thrown into the crusher, which consists of two cylinders armed with strong teeth, and which turn in opposite directions in such a manner as to break and crush the fresh bones.

After being crushed the bones are placed in boilers with water, where they are submitted to the action of steam for the purpose of extracting the grease, which, when collected, moulded, and bleached, is sold as bone tallow, at a price varying from 28*s.* to 33*s.* per cwt., according to the market. After the grease is extracted, the bones are thrown into heaps to dry.

The temperature of these heaps rises to above 60° or 70° cent. The mass undergoes a fermentation, and finally dries sufficiently to be screened.

The *débris* which passes through the screens is used to make bone-dust, which is brought to different degrees of fineness by grinding and bolting. One thousand to fifteen hundred tons of bone-dust are annually manufactured and sold to agriculturists for manure.

The new method of operating consists in the use of gas-retorts for the carbonisation of the material. Six retorts for carbonising the bones are now employed for this process. After the carbonisation is finished, the carbonised bone is emptied into sheet-iron coolers, where the mass is cooled without contact with the air, and the retorts are recharged. The gas and vapours which are generated in the retorts are conducted from the latter into refrigerating columns, which columns are composed of pipes cooled exteriorly, through which the gas and vapours circulate. To complete the condensation, they afterwards pass through a box, where they are submitted to a shower of water, from which they are returned to the furnace which heats the retorts, where the gas is finally economised as fuel.

The total quantity of black produced by MM. Dunod and Bougleux reaches 3000 tons per annum. They stand at the head of this industry in France, and have united in their establishment the best-known processes both for the manufacture of black and for the condensation of the ammoniacal water and the manufacture of sulphate of ammonia.

The production of sulphate of ammonia only uses up about a third of the bones employed, but about 1600 cwt.

of this salt is made annually. The average yield is 7 or 8 kilogrammes (16 lbs.) to 100 kilogrammes of bones, so that only about a third of the nitrogen in the bones is obtained; but this product is important.

Improvements in the manufacture of sugar have much diminished the quantity of charcoal necessary to obtain a given quantity of pure sugar; but, as the number of sugar refineries has much increased, and as the manufacture of sugar is every year becoming larger, the bone-black industry has rather increased than diminished.

In one beet-sugar establishment, that of Waghausel, in Baden, 32,100 cwt. of bones are used, for which 100,000 florins are paid, from which 1100 cwt. of bone-grease are made, 17,500 cwt. of burnt bones or animal charcoal are obtained, and 10,000 cwt. of refuse for artificial manure.

The scrapings, shavings, and saw-dust of bones and ivory is an article that bears a good price in the market, being much used by pastrycooks and others as a material for jelly, which it readily gives out to boiling water. The jelly thus produced is probably quite as good as that from calf's-foot; and the shavings, when dry, have the advantage over calf's-foot of not suffering any change by keeping. Another use of considerable importance to which bone-shavings are applied is in case-hardening small articles of steel.

When bones are submitted to destructive distillation the gelatin and albumen which they contain are abundantly productive of ammonia—hence a copious source of that alkali and its compounds; the residue is a mixture of the earthy part of the bone with charcoal, commonly termed bone-black. Bone-black possesses the extraordinary property of appropriating to itself the colouring matter of nearly all fluids that are filtered through it, and so powerful is its agency in this respect, that on testing the quality of some bone-black offered for sale, a dark-coloured claret was so completely discoloured in a single filtration through a depth of twelve inches of the black, as to be undistinguishable by the eye from the purest spring water. The introduction of this powerful auxiliary has created a complete revolution in the process of manufacturing and refining the beet-sugar on the Continent, and of cane-sugar in the sugar colonies of the East and West Indies. The only drawback to its use was its cost, because formerly it was thrown away as soon as repeated filtrations

had saturated the black with the colouring matter and impurities of the syrup to such an extent as to deprive it of its efficacy; but the discovery of a mode of renovating, or, as it is technically termed, "revivifying," the bone-black has obviated the difficulty, by enabling the manufacturers to use the same charcoal for an indefinite length of time with but little loss in quantity or quality. The process of revivification is simple and inexpensive.

Messrs. Leblay and Cuisinier have published a new process for reviving exhausted animal charcoal. They find that the power of absorbing colouring matter is restored on treating the charcoal with weak boiling solution of caustic alkalies. They also state that the original absorbing power of the charcoal may be very much increased by pouring over it a weak solution of bisulphate of lime.

Dr. H. Schwarz records the results of a series of experiments made with the view of ascertaining whether, by igniting bone-ash with organic substances, such as glue, size, sugar, &c., a good decolourising charcoal is formed, and also whether the spent animal black can be revivified to its former strength by a similar process. It appears from the author's extensive researches, that animal black may be entirely revivified in closed vessels by ignition with organic matter, which need not be nitrogenous.

By the following table it will be seen that the average of phosphate of lime from six samples of dry bone is about 50 per cent. :—

Bone of sheep	50·60	Dr. Thomson.
,, ox	45·20	
,, ,, ...	59·00	Berzelius.
Human bones	54·54	
Bones	37·70	Fourcroy.
Thigh bone of sheep ..	48·00	Bailey.
Average	49·17	

About a third of their weight is cartilage or gelatin, and the remainder earthy matters. The gelatin is extracted by boiling water under pressure, and is used to stiffen calico, &c.; when purified, it constitutes the nutritious aliment known as calf's-foot jelly.

When the bones are heated without access of air, the organic matter of the cartilage is decomposed, oily pro-

ducts passing over, and a black, carbonaceous residue being left; this is bone-black, or animal charcoal, greatly used as a deodoriser and disinfectant. Bones, when calcined and heated with sulphuric acid, yield superphosphate of lime, so highly esteemed as a manure. The last, and certainly the most important, application of bones, is the manufacture of phosphorus. The bones are first burnt, to remove all traces of animal matter; the resulting bone-earth, as it is called, is then subjected to the action of sulphuric acid, by which superphosphate of lime is produced. This acid phosphate is then mixed with charcoal and strongly heated in a retort, when it splits up into normal phosphate and phosphoric acid, the latter being finally reduced by the charcoal to phosphorus, while hydrogen and carbonic oxide are liberated as gases. The combustible and poisonous properties of phosphorus make it very dangerous to employ in the arts; but Professor Schröter discovered that when ordinary phosphorus was heated for some time in a closed vessel to a temperature of 470°, it lost its power of igniting spontaneously, and became of a deep red colour. By making use of this discovery, matches are now made without danger, either to those who manufacture them or to those who use them. The safety match is made by putting the oxidising material alone on the match, the red phosphorus being mixed with emery and pasted on the side of the box.

The animal matter of bones amounts on an average to about half their weight, or when dried to between 30 and 40 per cent.; so that they contain a large relative proportion of nutritive matter. The bones, including their animal matter, are the most durable parts of the animal fabric; hence the proposal of storing them up as occasional sources of nutriment, for not only is the cartilaginous portion unimpaired in bones which have been kept dry for many years, but it has even been found perfect in bones of apparently antediluvian origin. During the long journey of Franklin, Richardson, and the Arctic voyagers over the barren ground of North America, they sustained life in a great measure on bones. The best mode of extracting the nutritious part of bone for human food consists in grinding it first, and subjecting it with water to a heat of about 220° in a digester; or the earthy part may be removed by dilute muriatic acid.

The managers of the hospital of Montpellier make an economic soup of bones in the following simple manner. The bones are broken with a hatchet into pieces from an inch to an inch and a half long, with which an earthen pot is made two-thirds full. Water is then added, an earthen cover is adjusted, and the pot is placed in an oven immediately after the batch of bread is withdrawn. After remaining four hours, the pot is found to contain a very fat and glutinous soup. This being poured off, the pot is again filled with water, placed in the hot oven, and affords after an exposure of six hours broth less rich than before, but still of good quality. It is filled a third time with water, and being heated seven or eight hours, yields a fresh supply. These three portions are then mixed together, and being properly seasoned with vegetables, the whole affords a very nutritious and valuable article of diet. Thirteen lbs. of bones extracted from common meat produce 43 lbs. of broth, or sufficient for 400 of the hospital poor.

When dogs and some other animals devour bones, the nutritive part is abstracted by their gastric juice, and the earthy part is voided in their excrement, forming what was formerly called *album græcum*, a substance which had a fictitious medicinal repute, but is now chiefly valued by tanners.

"If," says Mr. A. Aikin, "we throw into the fire a bone, even of the most solid kind, and from which all oily matter has been carefully separated (an old tooth-brush will serve for an example), it will be found first to crack, and then to burn with a large and bright flame, in consequence of the combustible gases into which the animal matter of the bone is in part resolved. If the bone is taken out of the fire as soon as it ceases to flame, it will be found to be of a bluish-black colour, from the charcoal which is the residue of the decomposition of the animal membrane. If the blackened bone be returned to the fire, the whole of the charcoal is at length consumed, and nothing remains but the white earth of the bone, commonly called bone-ash.

"If instead of a single one a heap of bones is employed, and a fire is kindled in one part, it will spread by degrees to the whole heap, giving out more or less flame

and a strong heat; and in the treeless steppes of Tartary, and the pampas of South America, the inhabitants make up for the want of other fuel by burning the bones of their cattle, it being considered that the bones of an ox will produce heat enough to cook its flesh by. This, therefore, is another to be added to the many uses of bone. But by burning bone in an open fire, no other product is obtained from it except the ashes, while the horribly noisome odour of the gas which escapes combustion, renders this process a sore nuisance in any inhabited neighbourhood.

"The decomposition of bone by heat in close vessels, whereby the action of atmospheric air is excluded, is well worthy of minute attention, both in consequence of the large scale on which it is carried on as a process of chemical manufacture, of the importance of the products obtained, and of the interest which it possesses in a scientific point of view.

"The animal matter of bone is the only constituent part of this substance susceptible of decomposition by a heat brought up to low redness; in considering, therefore, the action of close heat on bone, the earthy ingredients may be considered as passive."

Mr. Pattee, of Warner, gives a formula for reducing bones, as follows:—Place them in a large kettle, filled with ashes, and about 1 peck of lime to a barrel of bones. Cover with water and boil. In twenty-four hours all the bones, with the exception, perhaps, of the hard shin bones, will become so much softened as to be easily pulverised by hand. They will not be in particles of bone but in a pasty condition, and in excellent form to mix with muck, loam, or ashes. By boiling the shin-bones ten or twelve hours longer, they will also become soft. This is an easy and cheap method of reducing bones. If the farmer will set aside a cask for the reception of bones in some convenient place, and throw all that are found on the farm into it, especially if one or two dead horses come into his possession, he will be likely to find a large collection at the end of the year, which would prove a valuable adjunct to the manure heap.

It is well known that the best means of preserving bones is to pass them through a caustic ley, which, removing the

grease and odour which they acquire, allows of their being kept in heaps, even many years. Bones may thus be preserved in pits, in the ground, or under water; the latter mode is preferable, if they are to be employed in a few months.

One of the most economical uses of gelatin consists in uniting it with bread in the form of soup. If it be well deprived of grease, it makes no alteration in the appearance of the bread, and prevents it from moulding so easily. The bread thus prepared is exactly like biscuit, if it be left a little longer in the oven. If the fat has been left in, a kind of cake may be made, of an agreeable taste, and which is more easily kept than that made with butter. When this bread has become dry, it may be pulverised under a rolling-mill, and a kind of flour is obtained, very savoury and nourishing, and suitable for making a good pottage, or for mixing advantageously with other aliments of a less nutritive quality. This flour is easily transported, and contains much nourishment in a small bulk.

In Paris the following is the process which has been long adopted for the extraction of gelatin from bones:—The bones employed are those of the head, the ribs, the legs of sheep and calves, &c., and those which are not useful for other purposes, except, perhaps, making phosphorus or ammonia. Those used by toy manufacturers (*tabletiers*) have as much of the gelatin extracted as can be done by ebullition.

When the heads of oxen are operated on, the teeth are first removed, and reserved for the fabrication of ammoniac, as affording a greater proportion of this alkali than any other of the bones. They then break the skull in such manner as to preserve all the compact parts in as regular forms as possible; these pieces present a surface of 20 to 30 square inches, and are steeped in a mixture of muriatic acid and water. They are left in this state in open vessels until a complete solution of the phosphate of lime has taken place, and the gelatinous part of the bone remains in its original shape and size, and is perfectly supple. When this operation is finished, which commonly lasts six or eight days, the gelatin is put into baskets, being first drained, and immersed a short time in boiling

water, in order to extract any small remains of grease, which would deteriorate the gelatin, and also to extract any of the acid which might be lodged in the pores. It is then carefully wiped with clean linen, and afterwards washed in copious streams of cold water, to whiten it, and render it more transparent. It is then put to dry in the shade. Two ounces of this gelatin are said to be equal to 3 lbs. of beef in making soup—that is, 3 lbs. of beef and 2 oz. of gelatin will make as much soup, and of as good quality, as 6 lbs. of beef. It is constantly used in some of the hospitals of the capital, especially in the lying-in hospitals. The ends of the bones, and such parts as from their porosity might still retain a portion of the acid, are separated, and used for making glue of a superior quality. The inside of the bones of sheep's legs furnish a sort of membranous glue, which supplies with advantage the place of isinglass in the fabrication of silk stuffs.

A few words yet remain to be said concerning the earthy basis of bones. This is, as I have already stated, a mixture of carbonate and phosphate of lime, the latter salt being in by much the largest proportion.

Many are the uses to which bone-ash is applied. When ground to moderately fine powder, it is the material of which the cupels of the gold and silver assayers are made, being at the same time very infusible and sufficiently porous to discharge the litharge and other impurities, while the fine metal remains on its surface.

When levigated and washed over, it forms an exceedingly useful polishing powder for plate and other articles, and is sold at about 1*s*. per lb. for this purpose. It is likewise the only material from which phosphorus is at present prepared. Part of the phosphoric acid is separated by the action of sulphuric acid from the lime with which it is combined in the bone-ash; and this portion, when mixed with charcoal-powder and strongly heated in an earthen retort, is decomposed; the phosphorus is liberated in the form of vapour, and is consolidated by coming in contact with the cold water in which the beak of the retort dips. It is afterwards purified by filtration through leather in hot water, and is finally melted, likewise under water, in conical moulds, by which it assumes the usual appearance of stick phosphorus.

Many are the things thrown away as useless which, when circumstances allow of their being collected in considerable quantities, are found to be applicable to a variety of useful purposes; and in none is this observation more remarkably exemplified than in the subject of the present illustration. Thus on investigation we find that bone contains a considerable quantity of valuable nutriment, which may be extracted with greater or less ease in proportion as its cohesion is more or less overcome—that in its entire state it forms excellent handles for small brushes, and is also applicable to a variety of other similar uses—that the worker in steel employs it for case-hardening small and delicate articles—that, in proportion to its weight, it is the most valuable and active of all manures, and contributes in no inconsiderable degree to improve and increase the agricultural produce of all the districts where it is employed—that, in the absence of other combustibles, it may be and is largely used as fuel in the plains of Tartary and South America—that, by its decomposition in close vessels, it produces hartshorn, ammonia, and animal charcoal—and that, when burnt to ashes, it becomes useful to the assayer, furnishes a valuable polishing powder, and is the material from which phosphorus, that curious and interesting substance, the most combustible of all solids, is produced.

Bone-black as a Manure.—Refinery black weighs about 95 kilogrammes to the hectolitre, and contains about 35 per cent. water; the black from sugar-making, nearly dry, weighs about 100 kilogrammes to the hectolitre.

The dried black contains, on the average, 65 per cent. of calcic phosphate; or if the black contains 35 per cent. water each hectolitre, 95 kilogrammes will contain about 40·130 kilogrammes of phosphate. Refinery black also contains coagulated blood, representing sometimes as much as 1·5 to 2 per cent. of nitrogen. Pure bone phosphate is worth in France about 27 to 30 centimes per kilogramme, and nitrogenous matter at least 2 francs per kilogramme of nitrogen, while refinery black may be obtained for from 15 to 17 francs the hectolitre.

Bone-black sold in this way is frequently adulterated by light carbonaceous powders, which diminish the weight of a hectolitre. A black could be made and sold for 7 francs

per hectolitre, which, at that price, would make the purchaser pay 49 centimes for each kilogramme of calcic phosphate contained in it.

The refuse of sugar refineries, which consists of animal charcoal, combined with blood and a little lime, has long been known and highly valued in France as a fertiliser of the first class, and immense profits have been realised by its employment. But, unfortunately, this animal matter is rather expensive, and commerce furnishes a quantity but very insufficient for agricultural purposes. An idea was therefore entertained of forming a manure which should possess almost identical properties, and which might be able to replace it, by turning to account the fæcal matters, disinfected by a cheaply-prepared charcoal. This new manure, which is called animalised black (*noir animalizé des champs*), is made from turf which is carbonised and then mixed with sewage-matter; a substance is thus obtained possessing several of the properties of the animal black of the sugar-refineries. In both cases we have an absorbent powder somewhat like charcoal, which takes up the ammoniacal compounds as quickly as they are formed, and which yields them back again but very gradually and slowly. This slowness and regularity in the production of ammonia forms, probably, one of the principal reasons that gives to the black of the sugar-refineries its value as a manure, and is especially advantageous in the present case; for the sole inconvenience in the employment of fæcal matters, when used as a manure according to the ordinary methods, consists in their too rapid and energetic action.

The process used in preparing the animal black at the works may be divided into two stages—first, the collection and disinfection, and secondly, the combining with the carbonised earth.

Two substances are employed for the purpose of disinfection, and with pretty equal success. The first is the residue from the fabrication of the sulphate of iron, which may generally be obtained at a very trifling cost. Another preparation often employed at the same factory for the purpose of disinfection is equal quantities of the foregoing with a solution of common soap. We have thus formed a metallic oleate, which appears to become more

readily decomposed than the sulphate under the influence of hydro-sulphuric acid and of hydro-sulphate of ammonia. In all cases the soap and fatty liquids are of use in this operation, for the purpose of forming over the surface of the soil an oleaginous layer, which prevents the diffusion of the hydro-sulphuric acid gas and other vapours.

This operation of disinfection transforms the volatile ammoniacal salts which exist in the fæcal matters into a fixed salt, *i.e.*, into sulphate of ammonia.

The fæcal matters, when brought to the manufactory, are turned into basins, and, by means of a shovel, are mixed with an equal volume of carbonised earth, the mixture being rendered as perfect as possible; and, after leaving it to settle for some time, the liquid portion is allowed to drain off at the lowest end by means of a sluice. The mixture is then removed, and spread on a hard floor beneath a shed or covering, and dried in the air, care being taken to frequently rake over and expose new surfaces, to facilitate the operation of drying. When the drying is complete, it is again returned to the basins, and a second portion of fæcal matters added, the mixing and drying process being conducted as in the former instance.

This process is repeated until the earth forms about a fourth part of the obtained product, which generally takes place on the third addition, provided the operation be properly conducted, and especially when the fæcal matters which are employed contain a large proportion of solid products.

This operation, which, under the employment of carbonised earth, gives out but a very trifling odour, occupies about one month in summer, and two months in winter; the most favourable season for the fabrication of this manure being the spring, and this season is best adapted for preparing the principal stock.

The mode of carbonising the earth consists in placing it on shelves in an oven, which is heated to dull redness; from half to three-quarters of an hour being required to carbonise each charge, and when removed from the oven, it is received into iron boxes; these are closed with air-tight covers until cool, when the carbonised earth is fit for use.

Bone has the advantage over ivory of being cheaper, harder, whiter, and little liable to become yellow by age,

and, when employed for small objects, may be had of a grain nearly as fine as ivory. The leg and buttock bones are chiefly sent to France; the shin bones are worked up for tooth-brushes.

In ivory cutting, on account of the curved form of the tusk in the direction of its length, its hollowness for about half its length, its gradual taper, and its elliptical or irregular section, it requires considerable skill to cut it economically. The only waste from this valuable substance should be from the passage of the saw, and this is sold to make jellies, while the refuse-tips, and other unworkable pieces, are of use in making ivory-black. Artificial ivory has been made by a French process, which consists in steeping the waste pieces and trimmings in acid solution; but it looks more like an opaque cement than like ivory.

The commerce in hides and bones from Australia and the River Plate has been much facilitated by the employment of carbolic acid. In some of the South American States the horses and cattle abound in a wild state, and are slaughtered by thousands at a time. Formerly one-half of the hides and bones were suffered to perish, exhaling an insupportable odour, as but few could be used for manure. The price of bones was then below 6*l.* a ton, but, by the use of carbolic acid, they now arrive in a serviceable condition, and, with the skins, can be used for all purposes that fresh bones and green hides are required for. The price of bones has been thus enhanced to 10*l.* and 11*l.* per ton. Hides often arrive in an advanced state of putrefaction, from having been rapidly dried in the sun or imperfectly salted. While the salting of hides necessitates long and expensive manipulations, they may promptly be preserved by immersing them for twenty-four hours in a solution containing about 2 per cent. of carbolic acid, and simply dried in the air. It is probable that from this quarter, ere long, the blood, the intestines, and other waste animal substances, may be imported into Europe at a profit by means of phenic acid, and converted into manure. In England carbolic acid is used to preserve the intestines, anatomical preparations, and, indeed, all animal matters.

Uses of Woollen Rags.—Rags from woollen materials undergo many peculiar metamorphoses; old clo' criers

first collect them; they are then successively converted into mungo, shoddy, and devil's dust, and reappear as ladies' superfine cloth; they then degenerate into druggets, and are finally used for the manufacture of flock paper. After undergoing all these transformations, they are used by the agriculturist as manure, on account of the large amount of nitrogen they contain. The presence of this element makes them of great use, also, to the chemical manufacturer; he boils them down with pearlash, horns and hoofs of cattle, old iron hoops, blood, chippings of leather, and broken horse-shoes, and produces the beautiful yellow and red salts known as prussiates of potash. From these, again, the rich and valuable pigment called Prussian blue is made, and thus do our old rags enter upon a fresh career of beauty and usefulness, to form, in their turn, other waste products, which may again be utilised through the power of man's intelligence.

Woollen rags, as they come from the rag-gatherers, comprise every variety of fabric that it is possible to produce from wool, from a coarse and harsh carpet to the finest and softest product of the loom. These are piled up in huge heaps upon the warehouse floor, and women and girls attack them on all sides and "sort" them into no less than ten grades, each of which has a special use and an established value. The greater part of these are manufactured into "shoddy," and, as this is a word concerning which a general misapprehension exists, it may be well to devote a few lines to its consideration.

Shoddy is, perhaps, the most abused material in use. So far from being a mere sham and a poor substitute for wool, it is, in reality, a valuable material, and enters, in certain proportions, into the composition of nearly all cloth. It is not, as is generally supposed, woollen rags ground to a powder and worked into the cloth to give it weight, but wool fibre, combed out of wool fabrics by a peculiar process, and, mixed with new wool, when the latter is carded, is spun with it, and finally becomes a component part of the cloth.

Thus, by mixing a due proportion of fine grade of shoddy or wool fibre with new wool of a coarse grade, a substantial yet soft and handsome fabric can be produced and sold at a moderate price; while the same thing, with fine high-

priced wool in the place of the much-reviled shoddy would cost far more and possess but little more value so far as wear and appearance are concerned.

The enormously increased production of wool in the last fifteen or twenty years has neither lowered prices nor done away with the using-up of shoddy or re-converted woollen rags. Besides the large quantity of shoddy and mungo produced at home, we import 67,560,000 lbs. of woollen rags torn up to be used as wool. The use of shoddy has now assumed gigantic proportions.

It has been well observed that the combination of shoddy with wool, together with the use of cotton warps, is the most valuable adaptation of materials in the history of the woollen trade which the ingenuity of man has discovered. By it multitudes of the humbler classes are enabled to obtain useful and comfortable articles of clothing, which formerly were beyond their means. Nor does it stop here. An immense mass of material, once thought all but valueless, has been rescued from the manure-heap, and made subservient to the wealth, industry, and comfort of millions. A feeling of prejudice or a smile of ridicule may rise at the thought, but manufacturers and consumers owe more to it than they are ready to admit. The manufacturers of pure wool goods are deeply indebted to it, for it has allowed them a full supply, which they could not have had, except at ruinous prices.

It often happens that the value of a thing is only discovered after its loss. Stop the supply of shoddy, and you may reasonably expect to double the present price of wool, and deprive millions of their warm and cheap winter garments, and their light and useful summer ones. Stop the supply of shoddy, and you will close one-third of the woollen-mills in the kingdom, and bring distress upon the West Riding of Yorkshire.

Some years ago rags containing less than fifty per cent. of vegetable fibre mixed with animal fibre of any kind were regarded as useless by the paper-makers, and thousands of tons were annually devoted to the manufacture of prussiate of potash, in which of course the vegetable fibre was wasted. All this is changed now, when attempts are successfully made to utilise everything.

As long ago as 1834 in the cotton districts they learned

how to put a cotton weft with a woollen warp. The cloths thus produced were finer in texture and cheaper than the woollen cloth, and therefore there was a great demand for them.

It was, however, scarcely worth while to take these muslin-de-laines as rags after they were worn out and economise them, because there were two fibres of different kinds, one of wool and one of cotton, and it was necessary to sacrifice one in order to get the other. For instance, if you desired to get the wool, you steeped the muslin-de-laines in acids, and converted the cellulose or woody fibre, of which the cotton consisted, into sugar; the cotton was lost, but the wool was obtained and used. If, on the other hand, you wished to save the cotton of this mixed fabric, you dipped the material into an alkali and dissolved the wool. The alkali did not dissolve the cotton, but the wool, being dissolved, was separated from the cotton, and the cotton was saved.

Mr. F. O. Ward, of London, showed at the International Exhibition of 1862 a pretty process for economising both fibres, or, at least, for getting a chemical product from each, which is very simple. The rags are subjected to a current of high-pressure steam at three or four atmospheres, that is to say, hotter than ordinary; and when this heated steam passes through the rags, it converts, without the aid of any chemical adjunct, the wool into a sort of bituminous or resinous matter, which becomes brittle. When this wool is dry it can be separated by a kind of combined beating and sifting process, and then there remains the cotton rags, which are sold to the bleacher and afterwards converted into paper. The wool refuse contains 12 or 13 per cent. of nitrogen, and is a good manure, being sold under the name of ulmate of ammonia. All the early broccoli which comes up from Cornwall is forced on by being manured with these woollen rags. Thus we have, as resulting products from these mixed fabric rags—a vegetable fibrous product, which is left on the sieve after the digested rags have been dried and beaten and sifted so as to separate the disintegrated pulverulent product of the animal threads, woollen and silken, and of the leather materials (old shoes, &c.), as the raw material (the animal pulverulent product, above mentioned as a manure, contains

nitrogen = 13 per cent. of ammonia); a kind of flock which floats off in beating the heated and dried rags, and which is available in making the so-called flock paper-hangings made in imitation of velvet; the fibrous vegetable product, bleached for paper-making—and I have samples of very good paper made of it.

The following is another patented process of an American (J. M. Collins, Albany, New York) for separating wool from rags of cotton and wool. Sulphuric acid and water, salt and alum, are made into a solution and boiled to a temperature of 10° to 19° (medium 13°). The rags are placed in the solution, and allowed to remain four to twelve minutes; they are then removed and rinsed in water, by which the cotton or vegetable fibre in the rags, destroyed by the action of the mixture, will separate and leave the wool.

Among animal substances, the waste from the carpet-looms in weaving is used for stuffing; waste from the winder-wheels is employed for making prussiate of potash; the mill waste for manure.

The shavings or waste in whalebone cutting also goes for stuffing or for manure.

In the making of prussiate of potash almost all the things which are too waste and too refuse to be employed in the higher purposes of waste substances, as cloths and paper-hangings, are employed. For instance, pieces of the horns and the hoofs of cattle, clippings of leather, the cast-off woollen garments of the Irish peasantry, and all sorts of things which are mere refuse, are mixed up with pearlash or carbonate of potash. Old iron hoops from beer barrels, broken hoops, iron nails, old horse-shoes, or any old scrap iron which can be obtained, is mixed up with this refuse, blood, and other substances, and they are all fused together in a pot, and afterwards dissolved out in water, then they are transformed from this ugly primary condition to the beautiful salt, yellow prussiate of potash, which is extensively employed because it is the source of Prussian blue.

Silk Waste.—The importance of this branch of the silk trade, already alluded to at page 67, may be judged of from the fact that for every pound of raw thrown silk produced (wound direct from the cocoon), there are left from 12 to 14 lbs. of waste, technically known as "frison," "ga-

letta," pierced and double cocoons, bassinas, &c. By the use of machinery for softening and dressing or combing this raw waste, the largest and best spinners of Switzerland, France, England, Germany, and other countries, prepare and spin it into yarn, which, being much cheaper and possessing greater evenness of thread, enters largely into competition with raw silk, being almost exclusively used in the finest ribbons and velvets, and also extensively in the manufacture of piece goods and sewing threads. 3260 bales of silk-waste were shipped from Calcutta in 1872.

The several kinds of silk waste are:—1. Husks and knubs in the gum. 2. Husks and knubs discharged of the gum. 3. Dressed waste, discharged, and cut to a uniform length for carding. 4. Dressed perforated cocoons. 5. Dressed husks and knubs. 6. Dressed China gum waste.

"The waste from spinning of floret silk is not thrown away, but serves as raw material for spinners, who make from it inferior qualities of yarn, which formerly were only very little used, but which now serve in large quantities in place of other materials. Silk waste consists partly of noils from floret silk manufactories, partly of thread waste from spinning mills and silk manufactories. It is spun on machines made for the purpose, by the application of the carding system, and appears in the trade under the name of bourette silk. It was formerly used for the manufacture of stuffs for gun cartridges. Later, F. Pasquay, of Wasselnheim, produced closer textures and webs, which were used for forage haversacks and tents in the French army. Pasquay, in the meantime, had made from the same material very pretty dyed burl-yarns, which have, however, been again supplanted by change of fashion. The firm of D. J. Lehmann began first, in 1867, to use these yarns as warp for waterproofs, and with increasing success, as the burling property of the texture lent a peculiar effect to the cloth. The present proprietors of the manufactory formerly belonging to Grelling Brothers, at Berlin, applied this material to the manufacture of satin plush, by making a texture with bourette silk (16-leaved) on one side, and raising it by carding. By this mode of treatment, also, the lustre of the silk showed itself to perfection. In Lyons, lately, this bourette silk has been used for closer stuffs with twill-face, and these stuffs are printed with steam

colours, in large patterns, for furniture coverings. There is hardly another more durable material for covering furniture. This article is also especially fit for dyeing purposes. It is necessary, before dyeing, to wash it thoroughly, and then dry. The drying process of this bourette silk does not present any serious difficulties. The treatment is the same as in dyeing ordinary silk, proper care only being taken for preserving and attaining as great a lustre as possible." (Dr. Grothes, *Must. Zeit.*)

Recovery of Oil from Wool, and Wool-washing, &c.—A method of separating oils, fats, and resins, from the solid substances with which they are mechanically combined has been heretofore in use for the purpose of removing the animal oil from wool, and also for the purpose of cleansing and restoring to use those portions of fleeces which have been made unavailable by marking the sheep with tar or other resinous material. It has been employed for supplementing the mechanical process of separating oil from seeds or olives by operating on the solidified residues which are known under the name of oilcake, *marc*, &c. At the International Exhibition of 1862, M. E. Deiss, of Paris, exhibited specimens of superior oils extracted in this manner from the *marc* of olives. M. Payen, in his report, has described the process as originally applied successfully to the cleansing of wool by M. Moison, of Mouy, Department of the Oise, in France.

A considerable economical advantage is obtained by this process, in the mere recovery for use of considerable quantities of wool which have been ruined by the pitch employed in marking. The animal oil separated has also some value.

The same process employed to dissolve the oils contained in strippings of machine cards in factories, which amounts to one third of the entire weight, is also the source of a considerable saving. This oil is what has been added in previous stages of the manufacture; and, after being thus recovered, it may be used again.

The wool which has been freed from oil by this process, on being subjected to the operation of the picking and beating machines preliminary to carding, yields a large proportion of fine fragments, or what may be called wool dust, said by M. Payen to amount to forty-two per cent of

the total weight. This is valuable as a fertiliser in agriculture, and is now turned to account. Under former modes of treatment it was a total loss.

But the application of the process has been more recently extended to a great variety of purposes. Thus, when the pitchy glycerine deposits formed during the saponification with sulphuric acid—which is made a preliminary to the distillation of fatty bodies—are acted upon by the bisulphide, they yield a considerable quantity of stearin amounting to eighteen or twenty per cent. of their weight. The waste grease of the kitchen, the exudations which take place from the axles of vehicles or the journal boxes of machinery, and all similar forms of oils and fats contaminated by impurities which, though they form but a small part of the weight, destroy entirely the value, are completely restored by this process, which recovers the valuable portion, and leaves the impurities behind. Rags, swabs, and fibrous materials of any kind, which have been employed in cleaning machinery or the parts of locomotives which it is necessary to oil, soon become saturated to such an extent that they are commonly thrown aside as useless; but these give up a large amount of oil to the solvent employed in the new process, which is in itself a gain; and the process also gives to the rags themselves a value which they had lost, since it permits them to be re-employed for the same purposes as before, or to be used in the manufacture of paper.

In the direct extraction of wax by pressure, there is left in the solid residue a proportion of twenty per cent. of valuable material which may be recovered by solution in bisulphide of carbon. This does not render the residue unfit for use as a fertiliser (the purpose to which it is commonly applied), but rather improves it. Sawdust which has been used for the filtration of oils purified by sulphuric acid, yields to this process fifteen or eighteen per cent. of its weight. The acid impurities separated from oils in the process of purification by agitation with a small proportion of sulphuric acid, furnish, by proper treatment with bisulphide of carbon, half their weight of pure oil.

Bones of animals obtained from shambles, from the streets, from kitchens, and from various other sources, are used to the extent of many million of pounds annually in

every country, for the manufactures of glue and of animal charcoal. These are usually to some extent exhausted of their oils by boiling, before being used in the manufactures for which they are intended; but the boiling separates only six or seven per cent., while the bisulphide process extracts ten or eleven. The oil cakes, which are formed in the mechanical process of the expression of oils from seeds of various kinds, furnish, as mentioned above, a large proportion of oil which the press has left behind. These cakes are sometimes broken up, reduced to powder, and pressed again with the aid of heat. But the labour of the second compression is greater than that of the first, and the product is less, while it still leaves the residue unexhausted. The cakes have a value as food for animals. It was at first supposed that the complete removal of their oil would injure them for this use, but experience has shown this impression to be an error. It is asserted by Messrs. Schlinck and Rutsch, to have been fully proved by experiments on a large scale already made, that in regard to the production of milk, butter, and flesh, the residues from which the oil has been thoroughly extracted are far superior to the pressed cakes, and that they retain their good qualities as food for animals though kept long in store.

The compacted masses, left in the extraction of tallow or lard by pressure, furnish twenty per cent. additional when treated with bisulphide of carbon. The residue from the compression of cacao gives a similar increase of product on similar treatment. Finally, the *marc* of olives, as exemplified in the exposition of Mr. Deiss, furnishes quantities of excellent oil which the press fails to separate.

The peculiarity of the industry of Messrs. Schlinck and Rutsch is that they do not take the trouble to use the compression process at all in their treatment of the oleaginous seeds from which the oils are obtained; that is to say, they do not first extract a portion of the oil by pressure, and then subject the residuum to the action of the solvent, as has been done by others before them.

A recent instance of the improved economy in the utilisation of waste is found in the treatment of the wool of sheep. It has been ascertained that sheep derive from the soil upon which they pasture a considerable amount of potash,

which, after it has circulated in the blood, is excreted from the skin with the sweat, and remains, generally in connection with this, attached to the wool. Chevreuil discovered, some time ago, that this peculiar mixture, known by the French as "suint," constitutes not less than one-third the weight of the raw merino fleece from which it is easily removed by immersion in cold water. In ordinary wools the suint is less, the amount being about 15 per cent. of the raw fleece. Formerly it was considered as a kind of soap, mainly for the reason that the wool, besides this, sometimes contained about 8 per cent., or a not inconsiderable quantity, of fat. This fat, however, is usually combined with earthy matters, mostly with lime, and consequently forms a soap which is very insoluble. The soluble suint is a neutral salt arising from the combination of potash with a peculiar animal acid, of which little more is known than that it contains saltpetre. Attention has lately been directed to suint, in order to obtain as much as possible of the potash eliminated from the animal, and a special industry has been established in various portions of the great French wool district, such as Rheims, Elbœuf, &c. Messrs. Rogelet & Co., of Rheims, received a silver medal at the Paris Exhibition in 1867 for potash and potash salts from suint. A company purchases from the wool raiser the solution of the suint obtained by rinsing the wool in cold water, the price paid for it being higher in proportion as it is more concentrated. As a general rule it is maintained that a fleece weighing nine pounds contains about twenty ounces of suint, which should contain about one-third part, or six to seven ounces, of potash, although not more than five and a half ounces are perhaps directly available. In the wool manufactories of the towns referred to, there are nearly 60,000,000 pounds of wool washed annually, the yield of about 6,750,000 sheep. This quantity should contain over 3,000,000 pounds of pure potash. Thus the water in which the wool is washed, and which has been heretofore thrown away, is made to yield a product, adding appreciably to the value of the wool itself, and more than covering the cost of its treatment. It is, of course, not an easy matter to utilise this solution of suint on a small scale; but wherever the work is carried on wholesale, as it is in connection with all great manufacturing establishments, it

will undoubtedly become a regular part of the process of manufacture.

The *suint* has been recently used as a substitute for potash in the manufacture of prussiates. Professor Havrez says, in *Annales du Gênie Civil*, that, according to the reports of the Chamber of Commerce of Vervicrs, Belgium consumed 98,000.000 lbs. of wool in 1868. England received from Australia and the Cape alone in 1872, 208,000,000 lbs. of wool and suint. One-third of this is suint, which would have furnished nearly 70,000,000 lbs. of potash and a large quantity of prussiate. When wool is cleaned by alkali in water, a portion of fat is removed, and in order to get the oily acids again from the water, Shearman treats the water with sulphuric or muriatic acid, heats the fatty acid separated from the liquid to 212° in a leaden vessel, saturates the free acid with chalk, adds hot water, stirs, and lets it settle for several days, when the fat can be drawn off clear. It may be reconverted into soap by alkali.

For spinning every 100 lbs. of washed wool, 12 or 14 lbs. of oil (mostly olive oil) are required: and extensive cloth manufactories use for fulling 50 or 75 tons of soap, each, yearly. There are, annually, 25,000 tons of washed wool spun in Austria, and about 3,500 tons of oil are consumed; the oil is valued at two millions and a half florins. This quantity which, until lately, has been entirely wasted, is again separated by fulling with soap. A writer describes a process in operation in Brünn, near Vienna, for saving this waste. It had been in operation for four years, and consists of the following manipulations: The soap water is collected in a reservoir from which it is pumped into a wooden tub. Sulphuric acid of 66° B., diluted with three times its volume of water, is then added under constant stirring, until the soap is perfectly decomposed. The fatty acids rise to the surface and, when cool, are collected, put into bags, and subjected to high pressure in order to separate the water as much as possible. After a few hours the bags are emptied, and the mass, which in the meanwhile has become consistent, is formed into cakes, to be molten at a temperature of from 350° to 400° Fah. and pressed again. The product thus gained is mostly used for the manufacture of soap, and it is estimated that the value of

the material reclaimed amounts in Austria alone to 350,000 florins.

The value of soap-suds as a stimulant of vegetable life, cannot be too highly appreciated. It contains the aliment of plants in a state of ready solution, and when applied, acts not only with immediate and obvious effect, but with a sustained energy which pertains to few even of the most concentrated manures. When it is not convenient to apply it in irrigation—the most economical method, perhaps of use—it should be absorbed by some material which may be used as an ingredient in the compost heap. Sods, muck, and other similar articles, should be deposited where the suds from the sink and laundry may find its way to them, and be absorbed, for the benefit of crops. In this way several loads of manure suitable for the support and sustenance of any crop, may be made at comparatively small expense. The highly putrescent character of this fermentable liquid qualifies it admirably for the irrigation of compost heaps of whatever material composed. Being a potent fertilizer, it must, of necessity, impart additional richness to almost any material to which it may be added.

The soap-suds from the scouring of wool fleeces and woven cloth or blankets is usually operated on with sulphuric acid, to extract the grease of the soap in wool, in the form of curd; from which is manufactured stearine, cloth-oil, and soap again. But from this, which is now a really valuable and extensive branch of manufacture, a new form of sewer and river pollution has arisen of the most offensive kind. The water left after the extraction of the grease is strongly acid, and, when run into a sewer or river, produces such an intolerable stench, that the most seasoned noses are unable to bear it; and it is said to poison cattle drinking from the rivers. This species of sewerage, called locally "magma," and also "seek" water, is now successfully treated by the patent processes of Messrs. Fenton and Woods of Dewsbury, for either purifying the acid magma water by a further extract of grease by precipitation, or by their filtration process; so that it may be mixed for manufacturing operations again, or run harmlessly into a sewer or river; or else by the extraction of the grease or magma from the suds without the application of acid to them at all. The adoption of either of these

plans requires no special plant, and, by securing a larger quantity of grease than the mode now in use, brings a profit to manufacturers, a benefit to the public, ease to corporations, and leaves in the refuse a valuable manure for farmers. From the extracted grease-mass obtained from the suds are made a half-boiled soap, black cloth milling soap, and a toilet soap.

I was much struck, at the International Exhibitions at Paris and Havre, with the illustrations of the utilisation of waste greases, shown by Messrs. Souffrice and Co., of St. Denis. This old house was the first to employ, on an extensive scale, steam and hydraulic pressure for the extraction of fatty substances. In 1860 they turned their attention to the pickings and waste from the slaughter-houses, and a return of 120,000 francs per annum was the result of their efforts. In the early part of 1863 they created a new industry for utilising the skimmings of the Seine. The Prefect of the Seine, considering the benefit that would arise to health by freeing the river from dead animals, floating grease, and other unwholesome matters, granted this house the exclusive privilege on the Seine for a small rent. In December 1864, Messrs. Souffrice and Co. proposed to the Prefect to undertake the removal of all greasy waters, and the waste and pickings of vegetables, in the twenty-five hospitals of Paris belonging to l'Assistance Publique; their offer was accepted, and a concession granted for six years. This led to the formation of an extensive piggery on their works, one of the largest in France, having continually feeding 600 to 700 head of swine. The firm was the first to utilise these pickings of vegetables, when cooked by steam, for the fattening of pigs, and more than 3000 fat pigs are annually sold, raised from this collected waste. In December 1867, Messrs. Souffrice and Co. fitted up two distilling apparatuses, to work another industry that had not been before attempted. The black residues from purifying colza oil, called fæcal acids, after distillation are by them turned out white, pure, and fit for the manufacture of soap. About 500,000 pounds of this substance are annually produced. In 1868 they conceived the idea of utilising the distilled tar, by combining it with turpentine and forming an excellent varnish, calculated to be useful to machinists and for ships, not only

from its good quality, but its low price. One hundred thousand francs are paid yearly by the above firm to various railway companies for the old grease, called "cambouis," which has served for greasing the axles of the wheels of the carriages. The purified products obtained are sold partly to the manufacturers of stearine, for saponification or for distillation.

From the residue of the manufacture is furnished, to farmers and cultivators, an excellent manure. The water in which flesh has been cooked, saturated with sulphuric acid and mixed with the urine of the pigs, is delivered gratis, about 50 hectolitres a day, to the cultivators of the sandy plains in the neighbourhood. With the pressed animal residue an excellent manure is made, to the extent of one million pounds a year, sold at 10*s.* the cwt.

Another firm that operates largely upon the recovery of waste fats and grease, &c., by sulphate of carbon, is that of Van Haecht and Co., of Molenbeck, St. Jean-lez-Bruxelles, which operates upon 1000 tons a year of these materials. They collect the residues from works that employ grease and oils, and all fatty matters, so as to recover every atom of grease. The waste from railways, from the grease-boxes, greasy rags, cotton which has been used for cleaning engines, are entirely cleared of the grease, and the cotton can be employed again. The sawdust which has been used for filtering oils, and the residues from tallow-melting, are made to yield from 13 to 25 per cent. of tallow. The residues from candle-works, and all other manufactures which contain any portion of fat, are brought into requisition.

Utilisation of Eggs and their products.—The clarification of wines in France requires yearly, at the rate of four eggs to each cask (of 225 litres) about 81 million eggs. But there is now sold annually (to the amount of 20,000 francs), a powder composed of albuminous matters, of little value, which is equivalent to 2 million eggs, and this economy is, of course, a service rendered to food-consumption. The white of eggs being largely used for making albumen, and various other manufacturing purposes, it is sought to find a use for the yolks, and the Society of Arts, London, and the Society of Mulhouse, France, have offered premiums for experimental inquiries in that direction. If the millions

of eggs of sea-fowl could also be more utilised, it would be a great boon to society.

In the manufacture of albumen from eggs, the yolk remains as a bye-product, for which a suitable application must be found to render this industry a lucrative one. Many makers sell their yolk at once in the fresh condition to the maccaroni and vermicelli makers, as well as to confectioners, but this kind of sale does not often produce any great activity. Hence the yolk is generally dried like the white of egg, and brought into commerce in the solid form. In this condition the glove makers mostly employ it, as they are compelled to use the yolk of egg for dressing glove-leather. They however prefer the fresh yolk, and for this purpose often break the eggs themselves, and introduce the dried white of egg into the market. This is done by the Thuringian glove manufacturers, who bring into the market considerable quantities of albumen as a bye-product, and sell it very cheaply. This albumen is mostly of inferior quality, not having been prepared with the necessary care, and, therefore, cannot be employed at all for roller-printing. At Arustadt, in Thuringia, where very large glove manufactories exist, which prepare their own yolk, the white of egg is dried by the bakers of the town, so that it cannot be surprising if the latter contains many impurities. The best kind of albumen is prepared by the Austrian makers; by far the greatest quantity of albumen consumed in the trade is produced in Bohemia and Moravia, because there hens' eggs are cheap and plentiful. The Bohemian and Moravian houses have, beside the places where they carry on their manufactory, establishments in many other towns, where eggs are broken daily, and the yolks retailed in houses for kitchen purposes. In this way the very best price is obtained for the yolks, which are turned to good account. The white of the eggs is collected and transported to the required manufactory for further use. The high price of albumen, and the evils attending its use, led, soon after its introduction into the trade, to an effort to replace albumen by a cheaper and more suitable medium, and many materials have been experimentally tried for the purpose, but hitherto without superseding the use of albumen. Animal caseine and vegetable gluten were, at first, particularly recommended

as successful substitutes; but these two bodies, and many others which have been proposed, have failed to prove their durability. They even lack the properties peculiar to albumen alone, and essential to their employment as thickening mediums—namely, solubility in water, combined with adhesiveness of the solution, insolubility with heat, without otherwise remaining pliant. Twenty-five years ago the Société d'Encouragement of Mulhouse offered a prize of 10,000 francs for the discovery of a material or process for replacing albumen in this respect in cloth printing, but hitherto no one has been found to whom the prize could be awarded. Z. Leuchs, of Nurnberg, proposed, indeed, to utilise for the suitable preparation of albumen the immense quantities of roes of fishes killed on the northern coasts of Norway and Sweden for the purpose of salting and curing, as containing a considerable percentage of animal albumen, and which were hitherto considered as worthless, or, at best, only fit for manure. His proposal, however, met only with a *succès d'éstime*, for A. Dollfus, who went to Norway at the instance of the Society, to make experiments on the spot as to how far these roes could be employed for the manufacture, gave it as his opinion that this preparation could not be practically carried out, as the albumen obtained was totally unfit for printing purposes. It resulted, in spite of numerous experiments, in the impossibility of preparing it free from the skin-like egg-shells containing the albumen; and it is evident that a product of this kind, mixed with finer or coarser insoluble bodies, cannot be employed for printing purposes. Leuchs was, indeed, rewarded for his idea by the Society's large gold medal, but the prize of 10,000 francs remains still to be drawn.

In the International Exhibition of 1862 the Russian Commission showed egg-oil in large quantities and of various qualities, the best so fine as to far excel olive-oil for cooking purposes; the less pure and very yellow qualities are chiefly used in the manufacture of the celebrated Kazan soap, which was also exhibited at the same time. Neither the oil for cooking purposes nor the soap are sufficiently cheap for general use; hence they are consumed only by the wealthy classes as luxuries, the soap being regarded chiefly in the light of a

cosmetic, and hence is a much valued addition to a Russian lady's toilet.

Milk as a Manufacturing Ingredient.—Milk now performs other offices besides the production of butter and cheese, and the flavouring of tea. It has made its way into the textile factories, and has become a valuable adjunct in the hands of the calico-printer and the manufacturers. In the class of pigment-printing work, which is, indeed, a species of painting, the colours are laid on the face of the goods in an insoluble condition,[1] so as to give a full, brilliant appearance. As a vehicle for effecting this process of decoration, the insoluble albumen obtained from eggs was always used, until Mr. Pattison of Glasgow, found a more economical substitute in milk. For this purpose butter-milk is now bought up, in large quantities from the farmers; and the required insoluble matter is obtained from it by purifying it from butter and free acid, and then drying it, at a price far below that of egg albumen. This matter the patentee has called *lactarin.* A second application of the same article, milk, has just been developed, by causes arising out of the enhanced price of olive-oil, the woollen manufacturers are now using the high-priced article mixed with milk. This compound is said to answer much better than oil alone, the animal fat contained in the globules of the milk apparently furnishing an element of more powerful effect upon the fibres, than the pure vegetable oil *per se.*

The many purposes to which whey may be applied have very probably been overlooked, and the utilisation of this refuse of milk in the process of cheese-making, especially in large factories, is becoming an important subject of inquiry. It has been generally thought that when used as food for pigs, it answers the only profitable purpose to which it can be applied. I have recently, however, seen it proposed to manufacture out of it milk-sugar, and it is said the process may be made remunerative. It is allowed that whey, mixed with barley-meal, is a good food for pigs, and that a high value may be set upon it for this purpose. The turning point for the cheese-maker is here again a monetary one. How many pounds of pork will a hogshead of whey make, and how many pounds of

sugar? What is the relative cost of converting it into pork or sugar, and what is the relative price in the market of the articles thus produced? To be, or not to be, pork or sugar, that is the question, and one to be decided upon by the money returns. The cost of converting whey into pork will be found, I think, to be less than that of making it into milk-sugar. Given, a trough, a pig, and a pig's appetite and digestion (which are seldom at fault), and we have pork. But what appliances, and what care and attention are necessary to extract from whey a portable and saleable saccharine matter? We are told that in Switzerland milk-sugar is made by allowing the whey to trickle down the sides of mountains in wooden gutters or troughs. Threads are placed in the gutters upon which the sugar adheres, and the watery portions of the whey pass off in evaporation. But then the Swiss are a practical and ingenious race. In England we cannot be expected to emulate the Swiss in this special direction. It will pay us better to buy pigs to make pork than to make hills to manufacture sugar. But certainly, if whey can be converted into any valuable material, and will pay for its conversion better than by feeding pigs, let it be done. I cast no doubt on this matter, place no difficulty in the way. The use of machinery in the present day is cheap, Milk-sugar would find a ready sale. There is no reason why we should always continue to give whey to the pigs, or throw physic to the dogs, if better purposes can be found for them. The utilisation of whey may be recommended to the serious attention of dairymen. The theory is good, and I hope the practice may be made profitable.

Manufacturers of cheese in the United States find whey more profitable as an article of nutriment for their stock, especially for calves, than it would be were it concentrated, crystallised, and purified as lactin. So long, therefore, as the manufacturers of cheese can get good prices for the calves they raise on milk-whey, it is not likely that the production of milk-sugar from it can be made remunerative.

Destruction and Utilisation of Rats.—As civilisation advances, human ingenuity is severely taxed to supply man's natural and artificial wants. Our grandfathers would have

said that the destructive vermin which infest our cellars under the name of rats would be the last thing which could ever be turned to a useful purpose. Even the fine lady of the present day, who piques herself on her exquisitely fitting gloves, would give one of those little shrieks, which she thinks so sweetly feminine, if told that the thumb of her glove was made of ratskin, as more elastic yet tougher than kid. The nineteenth century, in fact, sees rats elevated to an article of commerce. In Europe the fur of the rat is used by hatters, having been found to exceed in delicacy even that of the beaver. A company exists in Paris, on the principle of the Hudson's Bay Company, to buy up all the rats of France. Even in London many persons earn a livelihood by hunting rats in the sewers.

An ingenious individual of Liskeard, Cornwall, has, for some time past, been exhibiting himself in a dress composed from top to toe of ratskins, which he has been collecting for three years and a half. The dress was made entirely by himself; it consists of hat, neckerchief, coat, waistcoat, trousers, tippet, gaiters, and shoes. The number of rats required to complete the suit was 670; and the individual, when thus dressed, appears exactly like one of the Esquimaux described in the travels of Parry and Ross. The tippet or boa is composed of the pieces of skin immediately round the tail of the rats, and is a very curious part of the dress, containing about 600 tails—and those none of the shortest.

Few persons have an idea of the vast numbers of these vermin. Rats are to the earth what swallows are to the air, universally present. But, unlike their feathered rivals, we rarely see them, and hence are ignorant of the countless millions that burrow under our cellars, run up and down between our walls, haunt the sewers of great cities, and devastate the granaries of farmers.

Almost all the quarters of Paris abound with these vermin. The cellars and the drains are full of them. There are certain localities, however, where they are more abundant than others, such as the Rues de la Verrerie and Vielle-du-Temple, the neighbourhood of the old Opera House, and especially the entry of the passage des Pano-

ramas and the Boulevard Montmartre. They have a means of slaughtering thousands at a time in their annual rat hunts. The rats which infest the larger drains of modern Paris are driven by some terrifying process into the smaller or iron drain pipes, and being further pressed they are compelled to come out at the upper end, perhaps into the open street, or into some net, trap, or other contrivance awaiting them, by which their destruction is easily effected.

According to the French 'Moniteur' there are in France upwards of two thousand millions of rats and other rodents. Supposing each of these little quadrupeds to commit the damage of only one centime per annum, this loss would amount in the aggregate to twenty millions of francs annually. Hence it is most desirable to find some means of destroying this vermin in large numbers as expeditiously as possible. But it is about slaughter-houses that they "most do congregate." At Montfauçon the proprietor of a slaughter-house had a walled enclosure, where, one night, he threw the carcases of two or three horses, and then went quietly with his workmen, and stopped up all the holes, by which the rats had entered it, after which he went in, with these same workmen, each armed with a stick. The rats, thus entrapped, were slain by hundreds. In a single month he killed 16,050, and 2650 in one night.

There is a common pound in Paris, covering some ten acres, surrounded by a stone wall; and to this all dead carcases are brought. The bones of these animals are valuable, but then to be saleable they must be clean, divested of adhesive and often putrid flesh. To perform this operation by hand is both expensive and tedious, and as rats were found to be fond of horse-flesh, the authorities have colonised this horse-pound with rats by thousands from the catacombs of Paris, and they perform their work beautifully, so that the dead carcase put in over night is found a neat and polished skeleton in the morning. But as may be supposed, rats so well provided for rapidly increase, hence they have to be kept under.

Every three months a grand "battue" is made upon the aforesaid colony of rats, and all caught above ground die

the death of rats. The manner of doing this is curious. Horizontal and cylindrical holes are bored all around, in and at the foot of the enclosing walls—the depth and diameter being respectively the length and thickness of the rat's body. Upon the morning of the "battue," men armed with tin pans, kettles, drums, &c., rush in at the peep of day, and "charivari" the poor rats, who, frightened to death, poke their heads into the first opening. Of course all those in the wall holes have tails sticking out. The rat collector, with bag over left shoulder, now makes a tour of the premises, and the scientific and rapid manner with which the rats are seized by the tail, and safely (both to the rats and operator) transferred to the bag, challenges admiration. The privilege of gathering rats on the "battue" days is farmed out by the authorities, and a profitable business it is. These rats, sleek and fat as they necessarily are, fetch a high remunerative price—the fur, the skin, and the flesh meet with ready sales.

We do not eat the flesh of rats, but we do of pigs, and yet pigs are amongst the dirtiest-feeding animals of the whole creation. Most people are fond of ham, roast-pork, sausages, &c., the flesh of a well-fed pig. And why should not the flesh of a good, fat, corn-fed rat be palatable and good meat? Who has ever seen a fresh-skinned rat without remarking on the delicate-looking nature of the flesh? I certainly have never tasted it—indeed should require some very strong testimony as to its flavour before doing so; and yet one cannot help thinking that a nice, plump, young rat, fried or roasted, and served up with good gravy and other condiments, would make a very delicious dish. Strong prejudice would, however, seem to deter anyone in England from trying the experiment.

The Commissioners of Scinde, some time ago, issued a proclamation, granting head-money of 3*d.* per dozen for all rats and mice killed in the province, especially in the district of Hyderabad, the slayer having the privilege of keeping the body and presenting the tail. In China rat-soup is considered equal to ox-tail soup, and a dozen rats bring 2 dollars. A profitable venture might be made from Kurrachee to Canton and Hong Kong of salted rats. About 7,000,000 could be gutted and packed on board

of a 400 ton ship. The profits would be something as follows:—

7,000,000 at 3*d.* per dozen	£87,500
To salting and curing 60 per cent.	50,500
Total cost	138,000
7,000,000 sold at 2 dollars per dozen	256,666
The profit and loss will be estimated as follows:	
Cost of production and freight	138,000
Value at Chinese market	256,666
Profit	118,666

Let no man sneer at this. What we deem luxuries the Chinese despise, and *vice versâ*, we should also remember what is one man's loss is another man's gain.

In the West India Islands and other sugar growing colonies, rats prove very destructive to the sugar-canes, which they gnaw at the lower joints, and the air and wet penetrating causes the cane to rot, and moreover renders the expressed juice acid, so that in boiling the juice the sugar is frequently spoiled. At a moderate calculation 3 pounds of sugar are annually destroyed by each rat: periodical battues are made when the cane fields are cut, and rewards are given by the overseers of estates for every hundred rats' tails. They however increase enormously fast, having two or three broods a year, and sometimes as many as fifteen in a brood. In the island of Barbados, according to the sums paid for their destruction, there are killed on an average 100,000 yearly. The negroes are very fond of rats, and considering they feed only on vegetable food, they are probably not bad eating. The rat-catcher on a sugar estate is a recognised officer, and he gets so much a dozen for the tails he brings in. Rats are sadly destructive to the foreign mails, particularly on board the West India mail steamers, where they are large and voracious. It is curious, however, that these vermin will not touch letter bags of a tan colour. The Illinois Agricultural Society has undertaken the extermination of rats, by offering prizes of 50 dollars, 30 dollars, and 20 dollars for the exhibition of the largest number of scalps at its fair. One man has already obtained nearly 1500.

Rabbit and Hare Skins.—I have already given some statistical facts in connection with the collection and industrial uses of rabbit and hare skins; but a few more details of interest may be added with advantage.

The rabbit, by its fecundity, rapid growth, and useful products, is becoming more and more an object of attention in many countries for breeding, and although great complaints are made by farmers of the ravages of the wild rabbits on their crops, still rabbit warrens are maintained on many estates for the purposes of sport, even independent of the sale of the animals, which are frequently perquisites of the gamekeepers.

This branch of agriculture has been largely cultivated abroad, especially in the neighbourhood of the cities of Ostend and Rotterdam. It has been found that these rodents may be increased in a ratio far outstripping that of any other domestic animal suited for human food. Brought up on what are now termed "rabbit farms" (be it understood the practice has only within the last ten years assumed the gigantic extent it now enjoys), they consequently become objects of attention, and are not subject to decimation by foxes, weasel, dogs, poachers, and the multitudinous enemies of the rabbit warrens of Great Britain and Ireland. Even with these drawbacks, rabbit warrens are well known to be very profitable properties here. When the animals are as attentively protected as sheep, it is said that the rabbit farm pays far better than a sheep farm. Like that creature, every part is valuable and turned to account, the skins selling to the furrier at an excellent price, as high as 4*s.* a dozen being paid. Although in this work I profess to deal only with waste substances—and the skin is the product of which I have chiefly to speak—I cannot well pass over the general subject of the flesh of the rabbit as food.

The "rabbit season," as it is termed, commences in October, and lasts until April, or during six months. Hundreds of tons are weekly imported into London and Hull, where they are retailed at 9*d.* per lb.; the average weight of a young marketable rabbit is from 2½ to 3 lbs. The bones in them being very light in comparison with those of butcher's meat, the Ostend rabbit is considered a

cheap luxury, and is consequently in great demand by economical housekeepers.

The extent of many of the principal of these farms is somewhat surprising to persons who have not seen them, or heard them described, some of the proprietors sending off hundreds of tons in a season. The animals, being regularly fed, become domesticated. They are not of the same breed as the common tame varieties, as has been supposed; nor are they the common wild coney. Their flavour when cooked is excellent under any *cuisine*, not having the peculiar taste of the hedgerow or warren rabbit, so objectionable to some palates, nor the insipidity of the domestic species.

When killed and dressed for sale, rabbits sustain less injury during their carriage to market than most kinds of animal provisions, as they do not bruise. can be packed closely, and will keep fresh and wholesome for many days without ice, or any means of preserving them.

Few animals can be rendered such wholesome and profitable food for man, with a certain and increasing demand, within so short a time, as poultry and rabbits; nor are there any to which the tastes of the upper and middle classes of society are more partial, when they can be obtained on anything like moderate terms.

Rabbit soup tastes like chicken broth, but is far superior to it in flavour and nutrition, and highly recommendable for the sick. Rabbits breed almost all the year round. From her second year a doe will breed about six or eight times a year, bringing forth from eight to twelve or sixteen young ones each time. But the rabbit skins are in considerable demand for the hat trade, as has been already shown at page 69.

M. Hilliant has recently introduced a new method of preparing rabbit's hair for the manufacture of hats without mercury, which seeks to avoid the noxious mercurial vapours, and consists in the use of molasses in connection with the nitric acid.

At one time the skins of the silver-haired varieties, or silver sprigs, fetched 3*s*. a piece for ornamental linings to cloaks, &c. But the price has now fallen to 6*d*. or 8*d*.

The skins of other varieties, black, white, dappled,

or variegated, &c., serve for furs, and furnish the material for making infants' toys, an important manufacture in many countries. Other varieties, such as those known as the Cashmere or Angora, have hair 10 or 12 centimetres in length, which can be spun and made into silky stuffs agreeable to wear, of which specimens were shown at the Paris Exhibition of 1867, in the case of M. Moreau, member of the General Council of Aisne. In America this variety is much sought for for making shawls, and as much as 3*l.* has occasionally been paid for pure Angora skins of the age of five or six months only.

Rabbit skins when tanned and sewn together make very excellent mats, which I can confidently recommend for their usefulness, durability, and cheapness. The greater number of those who breed rabbits are ignorant of the industrial applications, and the collectors of rabbit skins, who are the intermediary agents for passing them on to commerce, take good care to keep up the ignorance, asserting that they purchase unwillingly this waste product which has but limited uses, and is but an insignificant traffic. Nevertheless it will be seen that the trade in rabbit skins is an object of great commercial importance. This may be judged of by the fact that in France the Administration of Public Assistance purchase them regularly at 6*d.* per lb., and, allowing for a waste of about 42 per cent., realise 10*d.* per lb. for them.

It is stated in the 'Encyclopédie Pratique de l'Agriculture' that the number of rabbits sent to the market of Paris, which in 1845 only amounted to 177,000 head, had risen in 1863 to upwards of two millions. Taking the consumption of Paris, according to the established rule, at one-thirtieth of that of the whole of France, the number of rabbits consumed must be set down at something over 70,000,000 per annum. Official documents fix the average price of rabbits at rather more than two francs per head, so that the total value must exceed five millions sterling per annum, and that of the skins is set down at another half a million sterling, as already stated.

Hare skins are another important waste product, which have many industrial uses. They are much used as chest preservers. Eight to nine million coney and hare-skins are exported annually from this country. About 150,000

hares are sold yearly in the markets of London; but the number consumed by private families, and which are received direct as presents, must be very considerable. They retail at from 3*s.* to 5*s.* In 1872, about 703,000 hares were sold by the licensed game dealers in the United Kingdom. From 350,000 to 400,000 hare skins are shipped annually from Smyrna; 50,000 to 1,000,000 grey hare skins from Russia, and a few thousand white hare skins, but these are scarce.

Hare skins form a considerable item in the exports from the Danubian Provinces, the chief market being Bucharest. This trade is mostly in the hands of the Jewish traders. The quantity is estimated at from 100,000 to 150,000 skins annually, according to the length and severity of the winter. The carelessness in shooting and skinning hares renders it necessary to count 110 as 100. The prices vary from 18*s.* 6*d.* to 28*s.* per 100 skins. About 34,000 dozen skins, at 3*s.* 6*d.* per dozen, are annually brought to Adrianople for sale; and 50,000 to 60,000 dozen are sent from Cæsarea to Trieste; 300,000 skins of the hare, fox, and jackal, are also exported from Tarsus to different ports.

The Disposal of Animal Refuse in America.—Having received from the writer (while this work is at press) the following communication, although now somewhat out of its regular order, I think it desirable to publish it, as indicating what is doing in this direction in the United States. Mr. S. P. Sharples, S.B., of Boston, states:—

"The disposal of animal refuse has become one of the most important problems of our modern civilization.

"With the growth of intelligence, and increasing refinement, people are no longer satisfied with the way that things have been carried on in past ages, but are continually demanding improved methods in every branch of art; and in no branch is this to be remarked more than in the preparation of food and in the disposal of waste material arising from such preparation.

"I purpose, however, to treat of but one branch of this great subject, namely, what is done now, and what can be done, with those parts of animals slaughtered for food, that custom or fancy has declared unfit to be eaten, as well as with those animals that die by accident or disease. In the more primitive stages of society, these gave little, or com-

paratively little annoyance. On the farm, but few animals are killed in the course of a year; and the earth, that most convenient of all disinfectants, soon absorbs and deodorizes their blood; whilst the rest of the offal is easily disposed of by burial, either in the ground, or, what is more economical, in the compost heap; and animals dying of old age or disease are also easily disposed of in the same manner. But as the population increases, so does the difficulty of disposing of this refuse augment. The slaughter-houses of large towns and cities become a plague spot, and a continual war is kept up between their owners and the community at large; a war in which the butchers have every advantage, except the moral one of right, upon their side. For it is an undeniable fact that people must eat, and so long as they must eat, some one must supply them with food; therefore, if they institute proceedings against the butchers, they generally get beaten. In close connection with the butchers, another business has grown up, viz., that of bone boiling and tallow rendering.

"There is no part of the animal that does not contain enough fat to pay handsomely for extracting it. These bone boilers and tallow renderers take all the refuse bones, heads, &c., together with those animals that have died from disease, and boil them for the sake of the fat they contain. When this is done, while the meat is fresh and untainted, but little annoyance is created; but too frequently no care is taken in this respect, and the stench is intolerable. Now there is no reason why this whole business should not be carried on with no more discomfort to the surrounding population than is occasioned by a well regulated market house or a carefully kept stable.

"A few days ago I had occasion to visit the establishment of Messrs. Ward & Co., which is situated on Spectacle Island, in Boston Harbour. The Messrs. Ward & Co. have the contract with the City of Boston for the removal of all animals, dying of disease or by accident, within the city limits. They also collect the bones from the market-houses, hotels, &c., and a great many from the various slaughter-houses in the vicinity of Boston.

"These are all delivered upon their wharf on Federal Street, from whence they are transported to the island. When they arrive there, the animals that are brought

down entire are skinned and then cut up; the remains are assorted and then placed in large iron kettles heated by steam; these kettles are provided with large, heavy covers which fit the rim tightly, thereby preventing the escape of steam. The pressure, however, is not allowed to rise above a few pounds to the inch, as otherwise the bones would be spoiled for many of the uses to which they are put. A few hours' boiling serves to completely separate the meat from the bone, and to extract most of the grease. The grease is then skimmed off, and the bones removed, if they are of sufficient size to be worth saving separately; the meat is then drained out, and finally the soup is dipped out and allowed to run into the sea. The larger bones are employed for making buttons and other articles that are formed from bone; the hoofs are used also in the manufacture of buttons, being first heated hot and then flattened out. They are also used in the manufacture of ferrocyanide of potassium. The bones are largely used in the production of bone char for the sugar refineries. The meat is employed in the manufacture of ammoniated superphosphate of lime; while the grease is manufactured into soap. None of these operations, however, except the mere boiling, are carried on upon the island; as they sell all their products to other parties to work up. The whole process, as carried on here, is filthy in the extreme; they follow exactly the same plans as were used twenty years ago, and the waste is enormous. They run tons of soup per day into the harbour; this soup contains about five or six per cent. of dry gelatine, and much of this is left upon the flats at low tide, and there putrefies in the sun. No attempt is made to preserve the blood, and this too follows the soup. The scrap meat is treated upon the premises with sulphuric acid from the kerosene works, and contributes its share to the general smell.

"I have chosen this establishment to describe, not because it was much worse than the rest, but because it gives a good illustration of how the business has been carried on. Men, when they are accustomed to any way of proceeding, are very hard to be persuaded to act differently, more especially if it cannot be proved, by actual dollars and cents, that a different method would pay better. As the bones and refuse are treated at this place, there is enough

grease left in them to pay for extracting by more improved methods.

"One of the first improvements suggested, was to treat them at a higher temperature: but this is not applicable to the larger bones, which may have some ulterior use; for bones, when treated for some hours in a digester, under a pressure of forty to sixty pounds of steam, are completely disintegrated and rendered useless for any purpose but that of the manufacture of fertilizers. For all the smaller bones, and for the meat, there is a great gain by the employment of increased temperature and pressure, as the fat is much more completely separated. The use of the digester has become almost universal in pork factories, and for treating the bones of the smaller animals.

"The use of the digester has another important advantage, as all the gases, given off during the process of steaming, can be led into the fire and destroyed or rendered innoxious. Before being led into the fireplace, they must be treated in some manner in order to prevent the extinction of the fire by the large amount of wet steam with which they are accompanied. This is accomplished at present in two different ways.

"First, by the Lockwood & Everett patent, in which they are conducted through about five hundred feet of iron pipe, arranged in the form of a coil and placed over a fireplace, by which the pipe is heated to redness; this superheats the steam, so that it does not interfere with the combustion of the gases, which are consumed by means of tuyers shaped like a Bunsen blast lamp, and placed immediately under the coil of pipe by which the gas is heated; the pressure of the escaping gas serving to draw in the air. In practice, however, this method seems to me to be too costly as the coils have to be renewed every six months, on account of the rapid oxidation of the hot iron by the steam.

"Another method which has been proposed, and in actual use to some extent, is to condense the waste steam from the tanks by either jet or surface condensers, and then to blow the gas under the grates of the furnaces used for heating the boilers (this is the method that they intend to use at Brighton, at the new abattoir). The gases, passing up through the heated coals upon the grate, will be decomposed, as in the Lockwood & Everett apparatus. The

tank or digester used for treating the meat and bones deserves a word of notice. The form most generally used is that known as Perry's, from the name of the inventor. This is a cigar-shaped vessel, provided with a steam jacket, and also with two hinged lids or covers: that at the upper end is simply an ordinary lid similar to the manhole cover of any boiler; the one at the bottom of the digester is, however, double; the inner, or false lid, being some eight or ten inches above the outer, or true lid, and perforated with holes. They are, however, firmly connected together, and hinged to one side of the mouth of the digester.

"The effect of this arrangement is to keep the scrap and bones from coming in direct contact with the true lid, and leaves a space from which the soup and grease can be drawn. There is no reason why these digesters should not be used also for treating the larger bones; the only requisite being, that the pressure should not be allowed to rise above a few pounds to the square inch. After the digester has been heated for a sufficient length of time, the main portion of the fat may be removed by blowing it off through suitable pipes, and then the soup drawn off at the bottom; or the soup and fat may be removed all together, and heated for some time until the fat rises to the surface, when it is drawn off and placed in suitable coolers.

"It has been the custom heretofore to throw away the soup as soon as the fat was removed; but, with the demand at present existing for nitrogen as a fertilizer, to say nothing of the nuisance created by the discharge of the large amount of putrescible organic matter into our streams, it seems that some application should be made of it. For instance, at the Brighton abattoir, they most likely will produce from ten to fifteen tons of this soup per day. This will contain, on an average, eight per cent. of solid matter, or 160 pounds in each ton, thus making from 1600 to 2400 pounds of solid matter, worth as a fertilizer, at the lowest calculation, three cents per pound.

"Mr. Wilson proposes to dispose of this soup and the scrap from the digesters, by converting them all into nitrogenized superphosphate of lime as follows. According to the best method of carrying out this process, the scrap, fat, and soup are all removed together into large lead-lined

tanks, which are heated from the bottom with lead steam pipes. If the specific gravity of the solution is too great, some water is added, and then a proper proportion of acid phosphate of lime, prepared from bone char, and containing a sufficient quantity of free sulphuric acid to dissolve all the bone contained in the scrap. The whole is then boiled; this has the effect of completely disintegrating the bone and tissue. The mass is then kept hot for twenty-four hours, at the end of which time all the grease has risen to the surface, from whence it may be skimmed off into clarifying tanks. It is found that the use of the acid phosphate, in connection with the char of the bone, completely removes any disagreeable odour that may be present, leaving only an odour similar to common shoe-blacking. It also destroys the gelatinous nature of the mass. The superphosphate, after the fat is removed, is then boiled down to a very stiff paste, and removed to drying rooms. As thus prepared, it forms an exceedingly valuable manure; specimens that I have analyzed containing from twelve to fifteen per cent. of soluble phosphoric acid, and from one and a half to two per cent. of combined nitrogen. The process, however, is open to several objections. In the first place, it is dependent on some external source for a constant supply of refuse bone char, or it must be carried on in close connection with bone-burning establishments; a few days' failure in the supply of char may render the establishment a nuisance.

"It makes no provision for the disposal of the blood of the animals killed. There are also frequently considerable quantities of sulphuretted hydrogen and other disagreeable gases given off during the treatment of the char with acid.

"It further requires a large capital for carrying on the business, as acid and char must be bought during the most favourable times, and stored until such a time as they may be wanted for use; a fraction of a cent per pound difference, in either of these articles, may convert a paying into a losing business, so small is the margin upon which the work is done. The product, too, is not so rich in nitrogen as it should be, and it cannot be much improved without too much expense.

"A second method of disposing of this refuse is by burning it, either wholly or partially; but I trust we are too rapidly

becoming aware of the value of fertilizers to long entertain this idea. Col. J. J. Storer, of Boston, has invented an apparatus for this purpose, that deserves notice, as it may be found profitable to use in those localities where fuel is abundant, or where the product is not of sufficient value in the market to make other means more profitable. He proposes to build a reverberatory furnace, with a large basin-shaped hearth; communicating with this directly is a large fireplace, in which the wet dung or other refuse material to be burnt is placed; directly in front of this is placed a smaller one, that he calls an auxiliary fireplace, in which a fire is also lighted. The coal pulverizer and fan communicate with this small fireplace. The scrap and bone are placed upon the sole of the furnace, and the fires are then started; the flame from the pulverized coal renders the dome of the furnace extremely hot, and the water in the tank-stuff is quickly evaporated, and any noxious gases given off from either the scrap or the large fireplace are burnt in this apparatus; a basin is also provided at the further end for the evaporation of the soup. When this is evaporated sufficiently, it is then added to the tank-stuff. I have been favoured with some specimens of the residue left on the sole of the furnace; it is completely inodorous, has a somewhat charred appearance, as if it had been overheated. It gives on analysis: Nitrogen, 3·09; phosphoric acid, 13·63; water, 7·13; thus showing it to be of considerable value as a fertilizer. It would make a good basis for a superphosphate; but more than half its value as a fertilizer has been destroyed by the process.* The method, however, has the advantage that it disposes of the entire refuse, without any offensive odour being given off during the operation.

"The last method which I shall mention is one that is being introduced to a considerable extent in Boston and New York. It depends for its success upon the fact that animal substances, when dried until they lose all but about ten per cent. of the water they contain, will keep indefinitely, provided they are stored in a dry place.

"This drying is accomplished by steam heat, by means of a machine known as the Hogel dryer. It consists of a

* "More recent specimens are said to show much better results."

large cylinder made of boiler iron, and provided with a steam jacket. There are suitable openings in this cylinder at the top for charging it, and at the bottom for removing the dry refuse.

"Through the axis of this cylinder runs a hollow shaft, which serves to conduct steam to the arms with which it is provided; these arms are so arranged in connection with proper stops in the shaft, that the steam passes out through one and in through the adjacent one: each two arms carrying attached to them a hollow scraper that passes near the side of the cylinder, and which serves to keep the refuse constantly stirred; the shaft and attached arms being kept in motion by suitable gearing. To add to the drying effects of the steam, a constant blast of air is kept moving through the upper portion of the cylinder. The consequence is, that in a period of time varying from two to four hours, the refuse is completely dried.

"The advantage offered by this machine is, that it receives and dries completely before they have had time to decompose all the blood of the animal, and also the scrap from the dryers. Indeed, in practice, it is not found desirable to dry the blood alone, as this is extremely difficult to accomplish; the blood sticking to the arms of the machine, and soon clogging it up. Nor is it, so far as I am informed, possible to treat the soup in this manner.

"The product of this machine is a reddish-grey powder, of rather a peculiar smell, but still not at all offensive. It is so clean and dry that it scarcely soils the hands when rubbed on them. The only use that has been made of it, so far as I am aware, is as a fertilizer, for which it is admirably adapted, as it gives on analysis:—

Water	10·22
Nitrogen	7·89
Phosphoric acid	12·15

"Whether it might form a valuable and acceptable food for hogs and fowls, remains yet to be tried; but I see no reason why, when mixed with a proper proportion of Indian meal, it might not be a valuable article of diet for omnivorous animals, provided it has been prepared from perfectly fresh refuse; the only danger to be apprehended being, from the amount of bone it contains, that it might tend to irritate the intestinal canal. But this bone, it

must be remembered, is so finely disintegrated and rendered so friable by the heat to which it has been subjected in the digester, that it may easily be crushed between the fingers. The gases given off by the Hogel dryer should be treated in the same manner as those from the rendering tanks.

"Mr. Shaw, in a patent that he has recently taken out, proposes to overcome the only disadvantage attached to the use of the Hogel machine, by converting the soup into size or glue. This he accomplishes by treating the soup with sulphurous acid and sulphate of zinc, and then boiling and allowing it to stand until it becomes clear. It is then drawn off from the precipitate that always falls, and evaporated in the usual manner. It produces a very clear glue of, however, rather inferior strength, but still good enough for many purposes.

"In this short account of means of disposing of refuse, I have only referred to those means which have more or less directly come under my own observation, and more especially to those for treating the substances that we are apt to regard as absolute waste.

There are other and important applications for many of these substances. The blood is used to a considerable extent in clarifying sugar, and some blood albumen is made from it. The scrap is also pressed and used for food for hens, &c. But these are only minor items in the vast account, and the process for carrying them out requires skilled labour and a large amount of capital. Those that I have described also require considerable capital to carry them on and could not be profitably employed were less than several hundred animals killed each day. The new abattoir company at Brighton, by associating a great number of butchers, will be able to dispose of all their refuse in the most economical manner, and in such a way, that it is hoped that no one off the premises need suspect, from any odours that arise from it, what is going on within. There is no part of the animal that is not worth saving for some purpose, and it has been too long a reproach against our great cities, that they wasted almost as much as they consumed."

Waste Products of the Fisheries.—In comparison with the large imports of guano proper, how infinitesimally small are the other animal manures, and especially fish guano

imported, looking at the immense utilisable wastes of the seal fishery, the whale fishery, the shark fishery, the cod, and other extensive fisheries.

From 1845 to 1860 we imported upwards of 2 million tons of guano, for which we paid nearly 25,000,000*l.* sterling. In the ten years ending 1870, it will be seen that we took nearly as much as in the previous fifteen years. But in the last two years we have had a failing supply, dropping to 178,678 tons in 1871, and 117,089 tons in 1872. Surely a commodity which sells here to the extent of one and a half or two millions sterling a year is worth competing for.

Imports and value of guano received in the United Kingdom, 1861–1870:—

Year.		Tons.		Value.
1861	....	178,423	....	£2,022,283
1862	....	141,636	....	1,635,322
1863	....	233,574	....	2,658,856
1864	....	131,358	....	1,457,088
1865	....	237,393	....	2,675,995
1866	....	135,697	....	1,439,679
1867	....	192,308	....	2,109,506
1868	....	182,343	....	2,039,478
1869	....	210,010	....	2,640,983
1870	....	280,311	....	3,476,680
		1,923,053	....	£22,155,870

We require at least 200,000 tons in the year, and, in view of the deficiency, would it not be wise to give more attention to the manufacture of fish-guano, of which the débris of the North American fisheries and those of the North Sea would furnish ample material?

With a fair margin of profit for such a commodity, it seems strange that the manufacture is not carried on more perseveringly and energetically, and the supply is not more extensive and continuous, with Europe for a market. It appears that about two-thirds, but say one-half, of the cod fish caught is thrown away in cleaning and curing, as waste or offal, so that out of 100 tons of fresh fish you have 50 tons for curing (reduced to 25 tons when dried), and 50 tons of offal. The average catch of cod-fish is by the Americans, 1,500,000 cwts.; by the French, 1,500,000 cwts.; and there is annually exported from Newfoundland 1,000,000 cwts. of dried fish British caught. The offal

from these, at the calculation of 1 ton to 5, ought to give about 40,000 tons of fish-manure in a perfectly dried state, from cod refuse alone available. As little or no value is set upon it at present, it may be estimated at little more than the price of collection, which, however, would be considerable. There are caught annually at Newfoundland about 500,000 seals, and the bodies of these, which constitute their chief bulk, must yield 50,000 tons at least of animal matter, after the oil had been tried out.

The livers of the cod-fish in years past were but little valued in the fishing-rooms of Newfoundland. But no sooner had Mr. Fox, an English chemist, arrived with suitable apparatus for rendering the liver, and preparing a superior class of oil, than the livers rose in price and were much cared for by those in charge of the oil-tubs and fishing-rooms. Mr. Fox also made known the value of the heads of the fish, which had been formerly thrown into the sea or on the manure heap, from which he manufactured large quantities of superior isinglass; and from the bones of the head remaining, after the chemical process which had extracted the isinglass, he made (with the addition of other substances) glue; thus turning what had for a hundred years been thrown aside as offal to valuable account.

In boat-fishing on the North American coasts, the fish offal is brought on shore in many localities and burned on the beach, but the stench arising from these deposits is sufficient to create disease in the neighbourhood. It is besides a waste of substance that might be turned into a source of profit. It is the opinion of many of the Gulf fishermen, that the offal when thrown into the water furnishes food for bait fish, and for this reason is beneficial to the cod fishery. It is, however, generally admitted to be a pernicious practice when pursued at the mouths of rivers.

The fishermen on the American shores use damaged, and frequently putrid fish as bait for mackerel. They are thrown into a box-hopper, in which a cylinder, studded with knives, is made to revolve by a crank. This is called the bait-mill, and by it the fish is reduced to a kind of paste, called "pohagan;" this is thrown into the sea to attract the fish.

The Jury of the London Exhibition of 1862 particularised the fish-manure of M. Rohart, who collected at the Loffoden Islands, in Norway, the heads and vertebræ of the cod-fish taken annually, and the produce of the fisheries there average annually 20 to 25 millions of cod, weighing in the aggregate about 100,000 cwts. This débris used to be wasted. He collected and dried them on the rocks by the wind, and then submitted them to steam pressure of 7 or 8 atmospheres, to deprive them of their elasticity and render them friable. When taken out with 20 or 25 per cent. of water they are dried in hot kilns, like those for malt, and after eight hours they become friable, and on submitting them to the pressure of millstones are reduced to powder. The cubic metre of heads dried in the air only weighs 67 kilogrammes, but the same quantity when reduced to powder weighs 670 kilos.

In the manufacture of cod-liver oil from the livers, the process adopted is far from obtaining all the oil, and M. Rohart conceived the idea of buying the livers, thus incompletely expressed, and after extracting the remainder of the oil, using the residue for his fish-manure, made as above stated from the heads, viscera, vertebræ, tails, &c., which was formerly thrown into the sea. A small portion of this waste is utilised for feeding beasts, as in the case of most of the northern countries by the coast.

The resinous deposit left in the steam-vats in preparing cod-liver oil, known as korg, is sold at about 5*s.* the barrel to the local farmers, who use it as manure, and irrigate their fields with the water in which this animal residue has been dissolved.

M. Rohart's fish-manure is in the form of a powder, very dry, and easily mixed with earth. Its odour is not unpleasant, and resembles that of salted herring or cod.

When ground pure it is very easy to adulterate. On the average this manure gives by analysis 9 per cent. of nitrogen, and 30 per cent. of phosphates. It is not only on the coast of Norway that this waste of the fisheries could be utilised. At Newfoundland there are thrown into the sea yearly 700,000 tons of this débris, to the injury of the fisheries. It would be possible to obtain from this 150,000 tons of fish-manure, and works could be esta-

blished that might prepare it to contain 12 per cent. nitrogen, and 14 per cent. of phosphate, which could be sold at 10*s*. per cwt.

A Norwegian association exhibited similar specimens of fish-guano at the Fishery Exhibition of Bergen in 1865. This guano, according to the experiments and analyses of Professor Storthardt, of Tharaud in Saxony, might replace Peruvian guano, for, employed for seeds in spring time and in the same quantity, it gave nearly the same results. From his analyses, and those of Orsted and Groth, and of Dittin, this fish-guano is rich, not only in organic principles, but also in phosphates, from 51 to 55 per cent. of the former, and 26 to 30½ of the latter. The analyses of Messrs. Girardin, Malaguti, Bobierre, and Is. Pierre, also demonstrate that this fish-manure is very rich in those elements indispensable for vegetable production, and approaches closely in its composition to Peruvian guano. There is nothing surprising in this, for they are both of the same origin. The fish in the one case have been treated by human industry, and in the other by the powerful digestive action of the sea birds.

There is an analogy, though not an identity, for the guano of Norway is in general less nitrogenous than that of Peru, but it is more rich in phosphates. This inferiority of nitrogen is compensated by the circumstance that this element is preserved in a state of durable combination while the manure is dry, decomposes slowly under the influence of humidity, and gives it off slowly to the plants. The average of analyses made by M. Bobierre gave for the Norwegian guanos 8·75 per cent. of nitrogen, and 27·75 per cent. of phosphates, while the mean of the guanos of Chili and Peru is 8·20 per cent. of nitrogen, and 20 to 25 per cent. of phosphates. The manufacture of these fish-manures ought to be encouraged, because it conduces at the same time to the benefit of the Norwegian fishermen and the European cultivators, and enables us to reclaim from the sea—that living reservoir of an ever during and inappreciable fecundity—some of the mass of fertilising matters which are carried off by rivers, to the detriment of our fields. The fish-guano made in Norway annually was stated a few years ago to amount to about 500 tons, selling at 10*s*. the cwt.

In utilising the waste products of the fisheries, considerable progress has certainly been made. Every description of fish is useful for some purpose or other, and very many, such as the dog-fish and others, which were formerly thrown away, are now largely used as food on the Continent.

The shark fishery is carried on in many parts of the Indian Ocean, and on the eastern coast of Africa, but lately it has been pursued on the coast of Norway. About Kurrachee, in India, as many as 40,000 sharks are taken in the year. The back fins are much esteemed as a food delicacy in China, from 7000 to 10,000 cwt. of these being shipped annually from Bombay to China. There are two kinds, known as white and black fins, which appear to be chiefly obtained from *Ryncobatus pectinata*, *R. lævis* and *Galiocorda tigrina*. White fins fetch 60*s*. the maund, black fins only 18*s*. When the fish are landed, the back fins, the only ones used, are cut off and dried in the sun on the sand; the flesh is cut off in long strips and salted for food; the liver is taken out and boiled down for oil; the head, bones, and intestines left on the shore to rot, or thrown into the sea. The rough skin of some sharks is used by workmen for polishing wood and ivory, and is also made into shagreen; lately I have seen the skin sold in London shops mounted as a file for rubbing corns.

The shark fishery affords very lucrative employment to the inhabitants of the northern districts of Norway, where it is carried on on an extensive scale, the four following species being met with: the Greenland shark (*Scymnus borealis*), the basking-shark (*Selache maximus*), the picked dog-fish (*Squalus acanthias*), and *Squalus spinax niger*. The fishery is carried on in boats of 25 to 35 tons, with a crew of six men, and, anchoring on the banks, they fish with seal blubber. The Greenland shark varies from 10 to 18 feet, and the liver yields from one-half to two barrels of oil. After taking out the liver, and inflating and tying up the fish again, it is thrown back, and floated away. When the fish can be towed to shore, the flesh is converted into food for the cattle, should the dry fish heads, on which they are usually fed, be scarce. It is also occasionally used as human food, being cut into long strips and dried in the open air, or buried in the ground until partially decom-

posed, when it is taken up and prepared in a peculiar manner. It requires, however, an Arctic stomach to digest it.

The basking-shark is harpooned; its size varies from 30 to 35 feet. This shark usually renders from five to seven barrels of liver; occasionally as much as from ten to sixteen. When the liver is rich, six barrels will yield five of oil, 30 gallons to the barrel. No other part of the fish is utilised.

The fishing for the dog-fish affords lucrative employment to the fishermen during the whole of the summer, from the Naze to the North Cape. This fish is sometimes eaten fresh, but must be skinned before being cooked. It is, however, mostly smoked, and in this way it is considered rather a delicacy. It is also dried as split stock-fish, for consumption in the country, as well as for export to Sweden, where it is greatly appreciated. The yolk of the egg, which is about the size of a pigeon's egg, is used by the inhabitants as a substitute for other eggs in their domestic economy. The skin is employed by joiners and turners for polishing purposes. The liver is exceedingly rich, and makes a very fine oil. The other dog-fish (*Squalus spinax niger*) is the smallest of the shark tribe. It is not eaten, but sought after exclusively for the liver, which is unusually rich, and yields a very superior oil.

On the coast of the United States, the flesh of the sword-fish (*Xiphias gladius*, Linn.) is eaten, both fresh and salted. Before being pickled the flesh is cut into slices, and it is said to remain good for a year, in Massachusetts several hundred barrels are put up annually.

Under the name of "offal" odd lots of fish, fresh and wholesome, but mostly small and broken, are bought at Billingsgate by those tradesmen who sell fried fish.

I cannot but conceive that we are a great deal too dainty in our choice of edible fish, much being rejected by the fishermen that would be wholesome and nourishing. The French are more thrifty in this respect. Notwithstanding the attention lately given to fish culture, our sea fisheries require to be largely developed. It is said that nearly a tenth of the population of China derive their means of support from the fisheries; and yet, with our sea littoral, how small is the proportion of persons who follow fishing

as a business. At a Maritime Congress, held during the Havre Exhibition in 1868, one of the questions propounded was whether attention might not profitably be given by the French to the seal, tunny, and shark fishery, as pursued so successfully on the Norwegian coast.

There are many fish oils that might yet be brought into use for commercial and medicinal purposes. For several years, M. Gobley, of the Paris School of Pharmacy, has prepared an oil from the liver of the skate, which is much less nauseous to the taste and smell than cod-liver oil. Professor Owen has also pointed out the services that might be rendered to medicine by the livers of various sharks and dog-fish, met with on our coasts, and especially in the tropical seas, which are rejected by fishermen. In India shark-liver oil is prepared in the ports of Mangalore and Tellichery, and at Nellore and Gantour in the Madras Presidency.

M. Collas, principal naval surgeon, and chief of the service of health in the establishments of French India, in the 'Revue Coloniale' for 1856, stated that he had found shark-liver oil equally as efficacious as cod-liver oil, especially as an internal remedy and in the cure of certain ulcers in the inferior limbs, common in tropical countries, and for which he had previously found no remedy. I fancy, however, that the shark-liver oil has such an offensive odour and unpleasant taste, that no mechanical or chemical process will remove it.

M. Collas stated that the solid part, which he called squalin, was an excellent dressing for certain ulcers and sores. A shark's liver, which cost him about 1½ franc, and weighed 15 kilogrammes, yielded 6·200 kilos of oil, from which there was obtained 1800 grammes of squalin. The oil is limpid at a temperature of 30°, turbid at 25°, and solidifies between 15° and 11°. Squalin, soluble in ether, is insoluble in alcohol, which gives it a yellowish colour, purified it melts at 36°, and by cold solidifies in the form of agglomerated tears, imitating the crystallization of antimony. By saponification only acids are obtained, which melt at 39°.

Oil from the white porpoise, the whale, seal, and little black porpoise (*Delphinus minor*), have been shown at the different International Exhibitions. The last oil has the

quality, peculiar to itself, of not congealing at as low a temperature as 34° Fahr., which only deprives it of its transparency. The greatest cold known in Canada in ordinary seasons, which causes other oils to coagulate, does not even render that of the black-porpoise less transparent. Whale oil costs about 1*s.* per quart. porpoise, black-porpoise, shark, and seal oils, when clarified, 1*s.* 3*d.*, cod, caplin, and sardine oils, 11*d.*

The skins of the marine mammalia, when properly manufactured, are stronger than those of land animals; this remark applies particularly to seal, porpoise, and whale leather.

Porpoise leather, looking at its strength, elasticity, and beauty, offers incalculable advantages over articles of the same kind. It possesses besides a particular property, which may be of advantage to many manufacturers, that of being of greater service than any other substance in the polishing of metals.

The catching of porpoises (*Delphinus phocœna*) is carried on extensively at the approach of winter in Denmark, when these animals attempt to leave the Baltic for the North Sea. From 1500 to 2000 of these are taken annually, which are worth 8*s.* or 9*s.* each. At the Faroe Islands the black-fish or bottle-nose (*Delphinus globiceps*) is captured largely. The fat is removed, some being preserved for domestic use, and the rest rendered into a fine oil. The flesh is cut into long bands as thick as the arm, salted and hung around the houses in the air to dry. The flesh has a black exterior coating, and soon exhales a disagreeable odour, which passes away when it becomes thoroughly dried, and it may then be kept a long time. The stomach is used to receive the oil made, and the fins and other parts of the animal are also utilised.

For a long time that delicious fish the caplin has been only applied for bait for the cod, or for manure. The 'Newfoundland Patriot' of July 4, 1862, writes thus:—"The caplin have 'struck in' at various points in Conception Bay, and we learn that the coves and beaches are alive with persons hauling this delicious fish for the compost-heap. It is an infamous shame to permit this valuable fish to be taken for manure, when it might be made a most

profitable article of commerce. If the thousands of barrels which are annually hauled for manure were manufactured as they might be—that is, smoked or dried, or preserved in tin, or as 'sardines'—they would sell readily and bring a good price, and give hundreds of our women and boys plenty of employment."

In May 1863, after a Committee had sat in Newfoundland to take evidence on the subject of the Fisheries, Mr. Rorke brought in a Bill in the Assembly, the first section of which prohibits the taking of caplin for manure, namely:—That from and after the passing of this Act no person or persons whomsoever shall haul, catch, or take any quantity of the fish called caplin, or of the spawn thereof, for the purpose of using such caplin, or any part thereof, for manure; nor shall any quantity of caplin, or spawn thereof, so caught or taken be used or applied for the purposes of manure, nor for any agricultural purposes whatever. And each and every person who shall haul, catch, or take, or cause to be hauled, caught, or taken, any caplin or spawn thereof, for any of the purposes aforesaid, and each and every person who shall, on any pretence whatever, use or apply, or cause to be used or applied, any quantity of such caplin, or of the spawn thereof as aforesaid, for manure, or for any agricultural purpose whatsoever, shall, for each and every offence, on conviction, forfeit and pay to Our Sovereign Lady the Queen, her heirs and successors, a penalty not exceeding one pound for the first offence, nor five pounds for any subsequent offence: Provided that caplin taken or hauled for the purposes of bait, and not used, may be applied and used for the purpose of manure, or any other agricultural purpose.

In one of the official consular reports it is stated that "Manure, which may now be considered as an article of Newfoundland trade, is manufactured on Massacre Island at St. Pierre in the following manner:—Old herring-bait, at a cost of two francs per barrel, is salted with foreign salt, then boiled in a furnace, containing 250 gallons, for three hours; when cold put into thick round mats, made for the purpose, about two feet in diameter, then placed under a screw about twelve of them at a time for twenty hours, by which process the water and oil are pressed out. These run, by means of a shallow trough and conducting

spouts, to casks outside the building, after which the oil floats and is taken off, yielding about five per cent. The mats containing the herring are put out, after pressing, to dry for two days, it is then taken from the mats, put into flour-barrels, and closely packed by treading upon it; some is put into boxes, containing 224 lbs. each; the barrel contains about the same weight.

Caplin and cods' heads are made into manure as above, but do not produce oil. Cods' heads are also well dried on the beach for five days or a week, without any salt. They are then packed in flour-barrels, screwed in, and sent to France, where they are ground up for manure. All these manures are said to be better than guano, and 50 per cent. higher in price. I saw mussels, oysters, bones, kelp, &c., ground to a powder, said to be equally good as any other kinds of manures. In the manufactory, which is about 60 feet long by 40 wide, I saw thirty screws fixed in frames over troughs; say five in each frame. The establishment could manufacture 20 tons per day with more room. Three hundred tons are sent to France. The island is not large enough to carry it on to the extent desired. There are no mills at present for grinding, but it is intended to import some, and fully complete the manufacture at St. Pierre. If these manures pay—and answer at so great a distance as France—why should they not answer for the inland agriculture of Newfoundland?"

In 1797, Mr. John Crooks, a chemist of Edinburgh, obtained a patent for a method of "making soap from fish of any kind, whether in their original unmanufactured state, or in a state of refuse, after they have been used in other manufactures; such as, for example, after the oil has been boiled or taken from them." "As fish" (he adds) "are often driven on shore in such vast quantities that they are either not used at all, or used only for manure; to prevent this public waste I put them into receivers, and, by pouring over them strong leys, sufficient to cover them, within two or three days after the fish is taken, or within such time as fish will commonly bear to be salted, I preserve them for being afterwards at leisure manufactured into saponaceous matter or soap."

Mr. Crooks goes on to state in his specification that he can also make soap from those vegetable substances which

contain saponaceous matter—such as potatoes, and even flour or rice—though seemingly among the least unctuous of vegetables. This is done by grinding those articles to a powder, and then using volatile alkalies with them. But to all, even soap from bones, he adds an eighth part of oil.

These soaps, he states, can be made in such cities as are far distant from great supplies of fish, but in which supplies of animals' bones, of vegetables containing saponaceous matter, and of urine may be found, such as in and round London, and the great inland manufacturing towns of Britain and Ireland.

Secondly. The soaps have no filthy smell, and, therefore, require no scent to overpower it; and lastly, from this circumstance, they are fitted for the use of distilleries, by keeping their fermentation down, and by affecting them with no bad smell. Moreover, most of them, such as rice, wash in cold sea-water, like fish-soap, and for the same reason, that there is no tallow in them; some of them, when long kept—such as soap from bones or rice—will become as hard as hard soap; some of them will lather, but in general they will not; a defect of no consequence to soaps, provided they do their business of bleaching and washing.

Shortly after this, a Mr. Unwin took out a patent for rendering soap-suds, after being employed in scouring, cleansing, &c., of sufficient efficacy to serve again for the like purposes, and to make soap from them. This was done by boiling and adding alkaline substances, till the scum, being saturated, disappears.

In the 'Comptes rendus de l'Académie des Sciences' for 1848 M. A. de Quatrefages wrote, "Sur la fabrication de l'huile de Hareng, et sur l'emploi du trangrum ou residu de cette fabrication comme engrais."

In order to utilise fish-fibre for the manufacture of paper, the fish are placed in a bath of diluted sulphuric acid (1 to $1\frac{1}{2}$ parts of acid to 100 of water), and kept there till the skins get loose, which happens in a few days when the fish are small. Then the acid water is poured off, and lime-water, or rather milk of lime, substituted. This neutralises the remaining acid, and removes all fat or oil, by forming an insoluble lime-soap. After some time, the lime-water, holding the lime-soap in suspension, is re-

moved, and fresh lime-water is added, till all oil is as completely as possible removed. This may be hastened by properly dividing the mass of fish. After it has been treated sufficiently with lime (for which also the more active soda may be substituted), the mass is washed with water, torn to pieces by proper machinery, and then soaked in a solution of hyposulphite of soda, common salt, and alum. Fish with a brown or dark skin are treated with a mixture of sulphuric and hydrochloric acid, after which they are washed with water, the skin is removed and the flesh separated from the bones. The flesh is then placed in a diluted solution of bichloride of mercury and alum till the fibres separate. After the fish-mass has been freed from all impurities in the manner described, it can be used as a paper pulp, and a paper may be manufactured from it, which, however, will have a semi-transparent appearance, very similar to parchment. It does not require any sizing, as there is enough gelatine in the fish; but it is necessary to smooth this artificial parchment after it is dried in the air, by passing it between rollers, or by pressing it between polished copper-plates. This parchment is, however, stronger and better, if from five to twenty per cent. of vegetable fibre, such as is used for making the ordinary kinds of paper, is mixed with the pulp. If as much as fifty per cent. of vegetable fibre is used, it is necessary to size the paper, and then it looks more like ordinary paper; while a pulp consisting of eighty per cent. of common paper pulp, and twenty per cent. of fish-fibre, cannot be distinguished from ordinary paper, except that it is stronger and tougher.

There are many other sources of such animal matters useful as manure: of these I may particularise the refuse of the glue and oil-boiling works, which yield annually a large quantity of nitrogenous offal, and the two analyses of seal and glue refuse which follow, by Professor Anderson, of Edinburgh, will show that, even when they are prepared without much care, they may become useful manures.

	Seal refuse.	Glue refuse.
Ash	36·21	53·18
Organic matter	41·85	38·60
Water	21·34	8·20

It would be of much importance to agriculture if none of

the human urine were lost. In respect to the quantity of nitrogen contained in excrements, 100 parts of the urine of a healthy man are equal to 1300 parts of the fresh manure of a horse, and to 600 parts of that of a cow. The powerful effects of urine as a manure are well known in Flanders, and they are considered invaluable by the Chinese, who are the oldest agricultural people. Its disagreeable odour; its erroneous modes of application, either in such excessive quantities, or mixed with other composts in such proportions that its powers could not be distinguished in the mass; its semi-fluid nature requiring for its removal carriages of a peculiar construction; and several other minor obstacles, have rendered its use infrequent in most countries.

A compound of urine and plaster of Paris, sold under the name of urate, is highly extolled as a manure. It is formed by mixing sand and burnt gypsum with urine, and forming a hard compound, which is afterwards reduced to powder.

Lobster-shell and Crab-shells for Manure.—Upon the coast of New England in the summer months immense quantities of lobsters are taken, and, after cooking, are placed in hermetically sealed cans and sold as food in all parts of the country. Some canning establishments in Maine consume in this industry thousands of tons each season; and consequently little mountains of shells accumulate, which are a source of annoyance to the owners of the factories. To utilise this product, the shells have been ground up and sold to farmers as manure. In order to ascertain the value of this substance, an analysis was made of a sample as sold in the market, and it was found to contain—

Water	15·90
Organic substances	42·13
Inorganic ,,	41·97
	100·00

In 100 parts there is of—

Ammonia, actual and potential	3·50
Insoluble phosphoric acid	4·00

The insoluble phosphoric-acid corresponds to 8·73 per cent. of bone-phosphate, and the remainder of the inorganic portion consisted of carbonate and sulphate of lime. We

learn from this determination that the lobster-shell manure has not a high value, is not worth as much as a good quality of fish pomace. I presume the article as prepared at different factories would vary considerably in value, but the analysis will afford a very fair idea of its actual worth.

There is a very small portion of the coast of the little State of New Jersey, U.S., not far from Cape May, which is infested during the months of May and June, and at no other season of the year, by swarms of huge crabs, about the size of a large soup-plate. Their flesh is too coarse and strong for food, and a "happy thought" struck a gentleman who was strolling on the beach, wondering, perhaps, for what purpose these animals were created; that, although not good for food themselves, they might become a cause of food if applied to the land; for he observed that the shell was not of a calcareous nature, like the common crab, the lobster, &c., but was *horny*, and therefore probably contained a large quantity of ammonia, which, as everyone knows, is a most material element in manure. Having satisfied himself upon this point, the next step was to secure so large a share of the profits of his discovery as would repay him for putting up machinery. This he had no great difficulty in doing, for, like a wise man, he kept his idea to himself; and as no one had ever conceived that there could be any possible value attaching to these great, ugly, crawling things, he secured for a very small sum the sole right of picking them off some two miles of beach, or bought the beach itself, I am not sure which. He then set up a crushing-mill, and employed people to collect the crabs, which are speared and thrown into waggons, just as our agricultural labourers pick up turnips to throw into the turnip-cutter, and they lie about as thick as turnips in a field. They are literally in myriads. They are then thrown together in heaps, the base of each heap being surrounded with hurdles to prevent their escape. Here they die a slow and cruel death from suffocation, much as the pearl-oysters in Ceylon do; and it will be easily imagined that they do not emit a very agreeable odour in the process, though they do not putrefy so much as one would expect, but rather dry up, thereby losing about four-fifths

of their living weight, or rather less. They are then thrown into the crusher and torn to pieces, but, not being dry enough to grind, they are further kiln-dried, after which they are reduced to powder. That powder is "cancerine," which is worth 6*l.* a ton at the mill, and is in great demand amongst the fruit-growers in Maryland and Pennsylvania. In 1871 about 400 tons of it were made, and considering that the crab-harvest only lasts two months, and that their visit is confined to so small a portion of the coast, this will show how numerous the creatures are. As to their eggs, one may almost say that the sand of the beach is eggs; and there is a story of a ship-captain, who was unacquainted with the peculiar character of the beach, loading his vessel with what he supposed to be some particularly nice clean sand. On the voyage the eggs were hatched, and, on arriving at his destination, he found that he had a live cargo to deliver, which the port authorities declined to receive, and ordered the ship out to sea, to the poor man's great consternation. One would have supposed that the same shrewdness which detected a possible value in what others had passed unnoticed would also have recognised the importance of carefully husbanding the supply of raw material for his novel manufacture, but the story of the goose that laid golden eggs is one that finds a wide application. No sooner was esparto grass found to have a value for paper-making than the greedy but lazy owners tore it up by the roots, in their eagerness to make a present gain, thereby destroying a permanent source of income. The same thing happens with these crabs. Not only is the voracious crushing-mill destroying the parent crabs by the million, but the eggs, which should be carefully cultivated, are scooped up by the bushel and thrown to the pigs and poultry. Looking to the great and increasing value which our high-pressure scientific farming gives to everything that tends to renew the exhausted producing power of the soil, it is a point worthy of the notice of our scientific men whether we cannot find on the rocks and beaches of our own coasts the means of carrying out the hint which New Jersey has given us. In a densely-populated country like ours there certainly ought not to be any waste, either of food or of food-making material.—(*The Food Journal.*)

The pounded shells of oysters, lobsters, cockles, mussels, &c., where they can be obtained in sufficient quantities, form useful additions to some soils. Crushed oyster-shells are very extensively used in Ireland, and on clayey and sandy soils. The shells of most crustacea consist of the same ingredients as bone, viz., about 6 per cent. of carbonate of lime, 14 of phosphate of lime, and 26 of cartilage.

The exuviæ of animals are of considerable use for several manufacturing purposes, as well as for fuel in some foreign countries. Horse-dung is used in making the cores or loose internal parts of the casting moulds for foundry purposes. Cow-dung is used in calico-printing, for fuel, and for moulding into children's ornaments in India. Dogs' dung and pigeons' dung are employed in the processes of tanning leather. Pigeons' dung is used to manure the sugar-cane lands in Egypt, being spread at the rate of ninety-five bushels to the acre, and twelve persons are employed to spread it. Camels' dung is largely used for making salammoniac in Egypt, and is moulded into cakes and sold for fuel in several countries. Guano, the dung of sea-fowls and coprolites, the fossil exuviæ of extinct animals, night soil, &c., form important and valuable fertilizers of land.

Night soil is sold as an article of commerce throughout the Chinese empire, in the form of cakes, mixed up with one-third of their weight of marl. Horse and other dung is also collected in the public roads and streets by the poor, and made up into cakes in the same way, which are dried in the sun.

Peruvian guano is a waste product which has become of extensive importance as a manure in most countries of Europe and the colonies. In 1850 the imports into the United Kingdom were but 117,000 tons, but many years ago it had risen to 300,000 tons per annum, although the consumption is now kept down by the increased price charged by the Peruvian Government, and the quantity of phosphatic artificial manures manufactured.

Mr. Braithwaite Poole, in his 'Statistics of British Commerce,' told us twenty years ago that " there are annually used in the United Kingdom 90,000,000 tons of farmyard or animal manures, exclusive of guano, nitrate of soda, and other artificial fertilizers, involving a money value of

25,000,000*l.*; anything, therefore, that would economise the labour of transporting and spreading bulky farmyard-manure, by giving us a more concentrated and portable fertilizer for our soils—anything that will render us less dependent upon the Peruvian Government for guano—must be hailed as a national boon." It therefore becomes an object of the greatest importance, both in a national and commercial point of view, to find so valuable a substitute for Peruvian guano; for, although the utilisation of the sewage of towns, of sea-weeds, and of the offal and inedible fish of our coasts has been discussed for years past, they have not yet become articles of commerce, so as to be available to any extent by the agriculturists of the kingdom.

The Use of Fish as a Manure.—The idea of converting fish offal, and fishes, that are not valuable for food, into a portable manure, was first carried into effect in France about 1859 or 1860, and establishments were erected in France and in Newfoundland for this object. The offal is placed in large coppers and heated by steam until thoroughly cooked, after which it is submitted to pressure, which extracts the water and oil. The pressed mass is then rasped, dried in a current of hot air, and ground to powder. One hundred parts of the recent offal yield, on an average, 22 parts of the powder, besides from 2 to 2½ parts of oil. One establishment. near the eastern entrance of the Strait of Belleisle, in a harbour which is greatly resorted to by vessels engaged in the cod-fishery, produced 8000 to 10,000 tons of manure annually.

Fish manure, having the same origin as guano, contains the same constituents, though not in the same proportions; for digestion, and afterwards the exposure of the dung, must have wasted much of the azotized matter, while the phosphates would almost wholly remain; whereas this guano retains them in the same proportions as they exist in the fish. Its very high per centage of ammonia (12 per cent.) renders it peculiarly valuable for corn and grass; to which is added the refuse of the fish houses, scales, &c., increasing the fertilising properties of the manure; the fish acting quickly, the scales more slowly, but all will be good, and no waste. Peruvian guano is inefficient, if applied in dry weather, and in this case is spoilt by dissipation of ammonia,

whereas the fish remains ready to act, as soon as the rains come. When a more rapid action is desired, mix it with compost, or sprinkle with urine, which will cause decomposition of the fish. Four to five cwt. is sufficient per acre.

Ammoniacal phosphatic guano abounds with fish-scales, the latter containing about 16 per eent. of nitrogen, and 40 per cent. of phosphates, together with the gelatinous liquid from the fish, absorbed by humus. The action of ammonia promotes decomposition, similar to bone-dust.

The refuse of herrings, collected at the places where this fish is eured, is found to be a useful manure. Fourteen barrels of herrings yield one of refuse in Scotland; pilehards yield rather less, but furnish more oily matter. At Yarmouth and Lowestoft the farmers use the herring-scales. The herrings are washed in large tubs previously to their being smoked, and the scales that come off in the operation are sold to the farmers at 6*d.* the last: each last contains the scales of about 10,000 herrings. These seales are sown upon wheat and elover lays, and harrowed in with the eorn, and from such treatment the erops are thought to reeeive eonsiderable advantage. The water in which the herrings have been washed is oily, bloody and strongly impregnated with the effluvia of the fish. Now this water might be received into reservoirs contrived at no very great expense; from these it eould, as oceasion served, be drawn and conveyed in watering-carts, either immediately to the fields that are in a proper state to reeeive it, or to a heap of sods intended for eompost.

It is estimated that the total yearly produce of the cod-fisheries of the North American eoast equals 1,500,000 tons of fresh fish; of this, one-half is refuse, and is thrown into the sea or left to deeay on the shore, which, if converted into manure, would yield more than 150,000 tons, equal in value to the guano of the Peruvian islands.

This fish manure contains, according to an average of several analyses, 80 per cent. of organic matters, 14 per cent. of phosphate of lime and magnesia, besides some eommon salt, a little carbonate of lime, small portions of sulphate and carbonate of ammonia, and only 1 per cent. of water. This proportion of ingredients renders it an invaluable fertilising agent, worth about 9*l.* per ton.

Two specimens of fish guano, made in Gloucester, Massa chusetts, subjected to analysis, gave the following results:—

No. 1.		No. 2.	
Water	17·26	Water	20·01
Ash	10·43	Ash	29·92
Organic matter ..	72·31	Organic matter ..	50·07
	100·00		100·00
Nitrogen	6·82	Nitrogen	6·50
Phosphate of lime	8·01	Phosphate of lime	24·74

The amount of water will seem large, but it is difficult and expensive to carry desiccation to a higher point; and therefore it may be assumed that about 20 per cent. of water in the substance is an unavoidable quantity, and may serve as a standard in estimating its value. The amount of phosphatic and nitrogenous matter contained in these specimens proves that they are valuable manurial agents, and well adapted to all the grass and grain crops.

Any one who visits the fishing establishments of the provinces of New Brunswick, Nova Scotia, Newfoundland, and the islands and coasts of the Gulf of St. Lawrence and Labrador, will obtain a knowledge of the vast quantity of fish and flesh offal annually thrown into the sea, or otherwise lost to every useful purpose. The garbage thrown overboard yearly from vessels fishing on the banks of Newfoundland, if properly preserved and manufactured with the annual growth of sea-weeds upon the shore, would fertilise the entire cultivated surface of the Eastern States and British Provinces; still the amount of animal matter thus referred to is far less than that produced by the inshore fisheries.

To the foregoing may be added the enormous quantities of *mytili* and other shellfish growing upon the shore, and which are not less applicable for the manufacture of artificial guano than the offal of the finny tribes. At many places on the shores fish are met with in such abundance that they are employed by the fishermen to manure the small patches of ground some of them cultivate. At the principal fishing stations, the refuse garbage and bones alone would supply a manufactory, and with good management, and the use of kelp, the offal might be transported

from place to place without inconvenience. Like the bones of terrestrial animals, the inorganic matter, or ash of the bones of fishes, consists in the greater part of phosphates of lime, or bone phosphate, with carbonate of lime, the fertilising properties of which are well understood.

The following is an analysis of a dry powder for manure prepared at Newfoundland some years since from the decomposed, dried, and powdered refuse of the cod fishery :—

Moisture	1 00
Nitrogenous organic matter	80·00
Soluble salts (common salts, carb. of ammonia) ..	4·50
Phosphate of lime and magnesia	14 10
Carbonate of lime	0·06
Silica	0·02
Magnesia and loss	0·32
	100

A Mr. Pettit patented a process of converting refuse and inedible fish into a pulpy homogeneous mass, by the action of sulphuric acid, and afterwards drying it by desiccation, or absorbing its fluidity by admixture with peat charcoal or other drying materials to render it portable, and easy of the most minute distribution; and as this substance contains not only all the elements contained in the true imported guano as deposited by the sea-fowl, who exist on fish, but, in addition, that portion which goes for the nutrition and building up of the animal structure of the bird, he infers that the manufactured article is much more valuable as a fertiliser than the imported one. Mr. Pettit having patented his process, it seems, upon considering the subject, finding the impossibility of bringing together the required quantity of refuse, to one or more large manufactories, came to the conclusion that the best mode of effecting the object he had in view was to grant licences to several parties around the sea-board, forming convenient districts to which the raw material could be conveyed with the least possible delay and expense. As the seas surrounding our shores are well known to yield an inexhaustible supply of fish of all sorts, both edible and inedible, their capture, it is calculated, can be readily effected by the hardy fishermen located around our shores, if a

remunerative price can be obtained for the refuse and offal.

Mussels are a good manure for wheat, oats, peas, or beans, and for beetroot (if put on extra thick), at the rate of 200 bushels per acre, spread fresh from the vessel and ploughed in *at once*—the seed may be drilled directly if needful; this quantity is equal, as far as I have observed, to 15 tons of farmyard manure. They cost from 15*s.* to 20*s.* per hundred bushels. Mussels will grow stiffer straw and better quality of corn than five-fingers (star-fish); the shells do good on heavy land, but I am not sure that there is any manurial property in them. Mussels make good stuff when mixed with road-scrapings and ditch-scourings; in fact, no better manure can be made than mussels, five-fingers, or sprats, stirred up with the "rubbish" of the farm.

Star-fish or five-fingers are capital manure for oats, 1½ to 2 tons per acre are equal to 15 tons farmyard manure; they are also used for wheat, but they force too much straw, and make it liable to go down before the grain is sufficiently forward to prevent injuring the sample. Two tons per acre will grow good mangolds. They are best ploughed in direct from the vessel, though some people often put them in a manure-hill, which is a good plan if the manure is poor; the cost is 20*s.* to 25*s.* per ton. Star-fish are collected in quantities by the Belgian fishermen to be sold for manure.

For oats or roots there is no manure like sprats; but they are difficult to procure, having been very scarce the last few years, and are chiefly bought up for the Kent hop-grounds; they fetch from 8*d.* to 10*d.* per bushel. Some farmers use them for barley; but, as a rule, fish spoil fine quality, the barley growing too frothy from them. The waterside farmer has a great advantage over his inland brother in this matter of fish for manure, the carriage being, comparatively, no expense, consequently thousands of bushels and tons are used in this neighbourhood.

Sprats were examined by Professor Way, and he found in 100 parts of this fish:—

Water	64·60
Oil	19·50
Nitrogenous matter	15·90

The mineral portion or ash formed 2·12 per cent. of the fish. 100 parts of this ash contained :—

Phosphoric acid	43·52
Lime	23·57
Magnesia	3·01
Per-oxide of iron	0·28
Potash	17·23
Soda	1·19
Common salt	11·19
	100

These researches are the more valuable, since, if, as is not improbable, our supply of guano may cease, it will then become a serious question, Can a supply of a somewhat similar composition be obtained from our great sea-fisheries?

In some seasons the sprats are so abundant that it pays the farmer of Essex to send his waggons 20 or 30 miles for them. As a dressing of some 40 bushels of sprats per acre is found an excellent application, surely some economical preparation of these fish, as, for instance, by the mere reduction of the amount of their watery portion by gentle evaporation, might render them available in far more inland districts.

The refuse matters of the pilchard and other fisheries, which have long been used as manure in Cornwall and Devon, are very powerful fertilisers. Large masses of sea-weed and fine sand abounding in finely-broken shells are extensively carted away in many districts by the neighbouring farmers. A few instances of the occasional abundance of fish on our own coasts may be cited:—In 1801, 10,300 hogsheads of pilchards were landed at St. Ives, where they were sold at 10*d.* the cartload for manure. In the interval between 1803 and 1814 immense quantities were taken for their oil only; the fish which had been pressed were sold for manure.

In Norway the refuse of the fish-curing establishments and all the inedible portions of the fish are employed in making a manure which sells at 5*l.* to 5*l.* 10*s.* a ton. It is principally sent to North Germany. In 1869 the heads and offal of 4,000,000 of cod were converted into fish-guano. These fish heads sell at from 5*d.* to 7*d.* per 120.

Chemical and mechanical means have been applied to the marine *fuci* and fishes and fish offal, until an artificial

guano has been obtained. The sources of the alkaline carbonate, chloride of sodium, and organic matter have been found in marine plants, the phosphates and carbonates of lime and ammonia in the bones of flesh and fishes, and after many experiments, carefully performed, they have been combined so as to form a cheap and portable manure.

At Long Island, in the State of New York, menhaden fish (*Alosa tyrannus*, *A. Menhaden*, Mitchell.) are manufactured into manure; the oil, which is very offensive, is extracted from the fish and employed for common purposes.

In the Bay of Peconic there are no less than six manufactories, consuming, in the aggregate, about 2,000,000 fish weekly. The fish are chiefly caught in Gardiner's Bay, where they abound in great quantities. They are taken in what are called purse seines, and can be caught in any depth of water. The fish are bought for 1 dollar per thousand. These seines some days catch 150,000 each. The manufactories are nearly all on different plans. Some use large tanks, in which the fish are placed, and into which steam is forced. A portion of the oil is extracted, and rising on the surface of the water, is skimmed off; the water is then drained off, and the refuse is pressed by hydraulic-presses or powerful levers. In another way of working used by one manufactory, the fish are placed in a large iron cylinder, similar to a boiler, and steam is let in at a given pressure, while the cylinder is made to rotate by a steam-engine. The fish are steamed from twelve to fifteen minutes, then turned out, and subjected to hydraulic pressure, which of course extracts oil and water together. This runs through pipes into tanks, where the oil rises to the top, and is taken off. There is a patent for this cylinder system, as it is called. The fish, after having been pressed, are dried on large platforms (some of them covering half an acre of ground), and when thoroughly dried, the mass is ground down to what is called fish guano, ranging in price from 25 to 35 dollars per ton, and is considered an excellent fertiliser. These manufactories employ from fifteen to sixty men each, and consume an enormous quantity of fish. That it is a paying business there can be no doubt, considering the amount invested in it, which is considerable, the manufactories costing from 10,000 to 60,000 dollars each.

During the year 1871, 24½ million menhaden were rendered into oil and guano in the United States, at a profit of 1,500,000 dollars.

At Great Yarmouth, for making manure, dog and refuse fish used to be bought up at 20*s.* per ton from the fishermen; clean herring scales at 4*s.* per swill of 2 cwt.; and livers in barrels at 16*s.* the cask.

Sardines abound in the seas which wash Japan, and it is sometimes difficult for small boats to make their way through them. Large quantities are taken by the fishermen. An oil is pressed from them, which is used for burning, but it is of very inferior quality, and gives off a thick black smoke. After the oil is extracted the residue is used for manure.

Fishery salt, which has been employed on the coast of Cornwall for curing pilchards, from containing 10 to 15 per cent. of oil and fish-scales is much used for manure.

Fish Manure.—It is strange how long some subjects take before they obtain firm hold upon the public mind, or become objects of practical utility and industrial application. Thus the utilisation of the sewage-manure of towns, of the sea-weeds, and the waste offal and inedible fish of our coasts, much as they have all been discussed for many years past, have not yet become articles of commerce, so as to be available to any extent by the farmers of the kingdom.

Mr. Braithwaite Poole, in his 'Statistics of British Commerce,' tells us that there are annually used in the United Kingdom 90,000,000 tons of farm-yard or animal manures, exclusive of guano, nitrate of soda, and other artificial fertilisers. This subject of fertilisers for our soils involves a money value of 25,000,000*l.* annually. Anything, therefore, that would economise the labour of transporting and spreading bulky farm-yard manure, by giving us a more concentrated and portable fertiliser; anything, indeed, that will render us less dependent upon the Peruvian Government for guano, will be hailed as a national boon. If but half the energy, a tithe of the capital, and a small share of the experimental research and skill applied to many engineering and mechanical undertakings had been directed to these important desiderata, we should long ere this have been reaping the benefit of a home manufacture

calculated to renovate and invigorate our soils, and add largely to the productive resources of the kingdom.

For several years past, project after project has been started to extend the use of fish-manure; but one after another has broken down, from some cause or other. Many years ago Professor Way, in a lecture before the Royal Agricultural Society, called special attention to the use of fish as a manure, and contributed much valuable information upon this important subject. He described the various methods that had been proposed, or were being carried out, for drying and preserving the fish; such as those of Mr. Pettitt by sulphuric acid, of Mr. Elliott by the use of alkali, of Mr. Bethell by the employment of tar oils, of Messrs. de Molon and Thurnysen by treatment with high-pressure steam, of Mr. Stevens (the contractor for refuse fish at Billingsgate) who incorporates the fish in superphosphate of lime, &c.

The West of England Fisheries and Fish Manure Company (Galway) wound up after a few months' trial, and wasting a large amount of capital. The Lowestoft French experiment was placed in the hands of persons possessed of little or no practical commercial knowledge. Mr. Pettitt's patent seems to have failed mainly from the indolence of the Irish fishermen, where the chief experiments were made, and the expense of sulphuric acid required for the reduction of the fish.

An association, the North Sea Fisheries Company, established itself at Lynn; and another experimentalist on the manufacture of fish-manure, Mr. Samuel Osler, of Yarmouth, also entered the field of production. Mr. Osler brought to the subject a large amount of local experience, extensive connections, sound judgment, and practical knowledge, which ought to have resulted in benefit to himself as well as to the agricultural community. He proposed entering largely into the manufacture of fish-guano, and relied chiefly for the raw material upon the supplies of waste fish and offal always to be obtained. Thus he says:—

"The waste and refuse of a great fishing port will supply the materials cheaply and without risk or outlay, and as it will be a great additional gain to a fishing adventure to obtain a certain and constant demand for all this waste

and otherwise unsaleable fish, the establishment of manufactories of fish-manure will lead to new fisheries, where, without such aid, they could not prudently be commenced. Yarmouth, the chief fishing-station in England, with the adjoining coast from Lowestoft to Aldborough, offers every advantage for such a manufacture. It employs near 400 boats, from 25 to 60 tons each. They ordinarily afford from 2000 to 3000 tons of broken fish and salt, selling at about 1*l*. 2*s*. per ton; besides the waste of 400 smoking-houses, sold as refuse; and from 500 to 700 tons of herring-scales, a substance containing a very large proportion of phosphates, and obtainable for 1*l*. 10*s*. per ton. This is independent of the waste from occasional gluts of dog-fish and others, useless for food, of which no account is taken, yet which are caught in very large quantity, and of which an unlimited supply might be obtained, if the fishers could obtain a sale. In some years so great is the glut of herrings at Lowestoft that they are carted by the farmers at 4*s*. 6*d*. per ton. An ample, cheap, and continuous supply would therefore be secured from the first, by simply taking from the fishermen what they will only be too thankful to sell; and the manufacture, which would be in every sense of the word a national benefit, may be carried on with no risk, small outlay, and large profit."

I need not dilate upon the relative value of fish-manure as an application to the soil, because this subject has already been well ventilated, and is perfectly understood by the farmers generally. The extensive and increasing use of Peruvian guano, even at its high ruling price, is an evidence of this. According to Professor Johnston, 10 tons of fish, as far as nitrogen is concerned, are equal to 66 tons of farm-yard manure. Fish-manure afforded by dried fish will give 16 per cent. of nitrogen, if the ammonia is fixed; in blood 12 per cent., guano 14 per cent., farm-yard manure and marine plants about 2 per cent.

On analysing different samples of Mr. Osler's patent fish manure it contained from 8 to 12 per cent. of ammonia; the difference arising from manufacturing fully or partially-salted inedible fish; the higher percentage being yielded without alkaline salts. The manure is prepared in a single day, without hydraulic pressure or grinding. The product

from salted fish is stated to be about four-tenths of the bulk or weight, and from fresh fish about three-tenths; consequently the cost of the manufactured article may be readily determined by the rate at which offal-fish can be bought—generally about 20*s.* per ton for dog-fish and others; and these rates will pay the fishermen to fish especially for them. Dog-fish yield a large quantity of manure, their muscular fibre being so firm; and there is also much oil obtained from the liver. During the process of manufacture the albumen becomes solidified, like the white of an egg, adding to the quantity and richness of the manure.

But this effort also broke down.

While the manufacture of fish-manure is being successfully prosecuted in France, in Newfoundland, in Massachusetts, and other coasts of the United States, it does seem somewhat strange that it has not yet been made an extensive branch of business on our own sea-coasts. With such fishing stations and sources of supply as Yarmouth, Lynn, Penzance, Mullin, Plymouth, Edinburgh, Dundee, Wick, &c., it is a disgrace that the boundless harvest of the ocean placed at our doors should not have been more freely drawn upon for food and for manure.

It is not every farmer who can avail himself of the superabundance of the fisheries to cart off to his land; but by a slight desiccation and suitable preparation large supplies of portable and valuable manures are available, and would be readily purchased throughout the country.

Mr. Osler combined with his patent the preservation of all the nutritive portions of fish for food, in a cheap concentrated and portable form. But with this and the other products, oil, gelatine, &c., which come in as profitable adjuncts to the manufacture, I do not here deal, confining myself chiefly to the consideration of the more important matter of manure for the soil.

Aside from this most important point, such a manufacture extensively carried out would even be of great national interest. It would enable a fishery to be established at every cove and nook that can shelter a boat, giving the blessing of abundant cheap animal food to the labouring population, genuine and economical concentrated animal manure to the farmer, a crew to man a life-boat at

every spot of danger, and an effective band of seamen for the defence of the country.

Some of the stout scales of many fish are converted into ornaments, threaded as bracelets, brooches, &c. A vase with bunches of flowers made of the golden scales of the kingfish, those of the callipeva, and the larger scales of the pirarucu of Brazil, was shown at the Paris Exhibition in 1867, made at St. Catherine, Brazil.

The bright, silvery scales of the small bleak (*Leuciscus alburnus*) and the dace (*Cyprinus leuciscus*) have a commercial value for making artificial pearls. It is rarely that the bleak is more than 6 inches in length. The scales are slender, and but slightly adherent, silvery on the belly, and on the back of a dark, greenish blue. They are caught solely for obtaining the substance which has been ridiculously named "Essence d'Orient," and which is an indispensable ingredient in the manufacture of artificial pearls. The nacreous matter which surrounds the base of the scales is all that is useful in the fish. This liquor is also found in the chest and belly; the stomach and intestines are therefore kept. To preserve them from putrefaction, they are placed in ammoniacal liquid; notwithstanding which precaution, in sultry weather, it becomes black and infectious, after having acquired its phosphorescence. The fishery is prosecuted throughout the year, by means of line and hook, but it is chiefly in the spring, when it is cool, that it is most attended to, and largely in the Seine. The fish is very prolific.

To procure the Essence d'Orient, the fish are scaled with a sharp knife over a bucket or tub of pure water. The first water is poured off, as it is usually fouled with the blood and mucous liquor from the body of the fish. The scales are then washed in more water, in a sieve held over the bucket. This essence or solution passes through, and is deposited at the bottom, from whence it is ultimately collected. The scales are rubbed a second or third time, to obtain all the nacreous or silvery deposit.

Other Animal Waste from the Sea.—I will not go so far as to term sponges and corals, seals and sharks, waste substances, because these are now systematic fisheries and the products are important articles of commerce; but there are

many minor products obtained from the sea which are utilised, and which would else be wasted. Such are the marine shells thrown in abundance on many sea-shores, and obtained with facility in some quarters, which have of late years assumed a commercial value for different purposes. So also with the refuse and waste from many of the large fisheries. Five or six millions heads of cod, &c., were converted into fish guano at the Loffoden Islands in 1870, and four millions in 1869.

Marine Silk.—Among the many novelties which industry obtains from the ocean, one of the most curious is the textile fabrics which are made with the byssus of the *Pinnas* of the Mediterranean—the fin-shells or sea-wings as they are termed. The shells, which are in general very fragile, resemble in form those of the larger species of mussels, being long and tapering, narrow at the beak, and gradually expanding to a considerable breadth towards the opposite extremity. This mollusc, like most of its order, has the power of spinning a viscid silk, but not in the same manner nor for the same end as the caterpillars. The latter, seeking for protection during a certain stage of life only, have organs which, during the rest of their existence, are preparing for this end; but the *Pinna* has a constant use for this production, which, although like silk, a secretion of certain organs within its own body, acts as an anchor, a leg, or a hand, as may be required. The operation of the worm may truly be called spinning, but that of the mollusc is rather like the work of a wire-drawer, the substance being first cast in a mould formed by a sort of slit in the tongue, and then drawn out as may be required. Its mechanism is very curious. A considerable number of bivalves possess what is called a byssus, that is, a bundle of more or less delicate filaments, issuing from the base of the foot, and by means of which the animal fixes itself to foreign bodies. It employs the foot to guide the filaments to the proper place, and to glue them there; and it can reproduce them when they have been cut away. Their true nature is scarcely yet understood. Reaumur believed them to be spun from a secretion in the foot. Poli thinks them to be merely prolongations of tendonous fibre. The *Pinna* possesses a machine as incontestably mechanical as that of a wire-drawer's mill. It is provided with an ex-

tensile member like a finger, and this contains a glue which the animal protrudes at pleasure by means of a variety of minute perforations in the lip. This glue or gum, as in the instance of the common spider or the silkworm, having passed through these apertures, becomes threads of almost imperceptible fineness; and these, when joined, compose the silk which is so much admired by the Sicilians. But the animal first attaches the extremity of the thread, by means of its adhesive quality, to some crag or pebble of unusual size; and when this is effected, the *Pinna*, receding from that point, draws out the thread through the perforation of the extensile member by a process which Paley, in describing the similar operations of the terrestrial silkworm, justly compares to the drawing of wire. One difference alone exists: the wire is the metal unaltered, except in figure; whereas, in the forming of the thread, the nature of the substance is somewhat changed, as well as the form; for, as it exists within the worker, it is merely a soft and clammy glue, the thread acquiring most probably its firmness and tenacity from the action of the air upon its surface at the moment of exposure. This byssus forms an important article of commerce among the Sicilians, for which purpose considerable numbers of *Pinnæ* are annually fished up in the Mediterranean from the depth of twenty or thirty feet. An instrument called a "cramp" is used for the purpose: it is a kind of iron fork with perpendicular prongs, eight feet in length, each of them about six inches apart, the length of the handle being in proportion to the depth of the water; for, notwithstanding the extreme delicacy of the individual threads, they form such a compact tuft that considerable strength is necessary in separating the shells from the rocks to which they adhere. The tuft of silk, termed by the Sicilians "*lana pinna*," is then broken off and sold to the countrywomen, who wash it in soap and water. They then dry it in the shade, straighten it with a large comb, cut off the useless root by which it adhered to the animal, and card the remainder. By these means a pound of coarse filaments is reduced to about three ounces of fine thread. This is fabricated into various articles of wearing apparel, such as shawls, stockings, caps, gloves, purses, and waistcoats. The web is of a beautiful yellow brown, resembling the burnished gold hue which adorns the backs of some

splendid flies and beetles. A considerable manufactory is established at Palermo; the fabrics are extremely elegant, and vie in appearance with the finest silk, while the colour does not fade. The ancients made this an article of commerce, greatly sought after, and the robes formed of it, called tarantine, were very much in esteem. It is said that the scarf of the turban of Archytas was made of this fibre. It was known by the name of pinna wool, and by the Tarentines as *lana pisca*, or fish-wool. St. Basil, Bishop of Caesaria in Cappadocia, mentions it in one of his homilies, saying, "Whence had the pinna its gold-coloured hue—that colour which is inimitable?" (Stolberg's 'Travels,' vol. ii., p. 151, translated by Thomas Holcroft.) Gibbon states that the Romans called the pinna the "silkworm of the sea," and Procopius mentions that a robe made from the silk was the gift of a Roman emperor to one of the satraps of Armenia. In the year 1754 a pair of stockings were presented to Pope Benedict XV., which, from their extreme fineness, were enclosed in a small box about the size of one for holding snuff.

In Aufrere's 'Travels' is a description of the mode of collecting these shell-fish by the Neapolitans, and of the manufacture of different articles from the silk:—

"As soon as a pinna is discovered, an iron instrument called *pernonico* is slowly let down to the ground over the shell, which is then twisted round and drawn out. When the fishermen have got a sufficient number of them the shell is opened, and the silk, called *lana pinna*, is cut off the animal, and, after being twice washed in tepid water, once in soap and water, and twice again in tepid water, is spread upon a table, and suffered to become half-dry in some cool and shady place. Whilst it is yet moist it is softly rubbed and separated with the hand, and again spread upon the table to dry; when thoroughly dried, it is drawn through a wide comb, and afterwards through a narrow one. These combs are of bone, and resemble hair-combs. The silk thus combed belongs to the common sort, and is called *extra dente;* but that which is destined for fine work is again drawn through iron combs or cards, called *scarde.* It is then spun with a distaff and spindle, two or three threads of it being mixed with one of silk; after which they knit not only gloves, stockings, and waist-

coats, but even whole garments of it. When the piece is finished, it is washed in clean water mixed with lemon-juice; after which it is gently beaten between the hands, and finally smoothed with a warm iron. The most beautiful are of a brown cinnamon and glossy gold colour." A pair of gloves made of the pinna silk may be seen in the British Museum. The best products of this material are made in the Orphan Hospital of St. Philomene, at Lucca. At Paris, in 1867, Paul Montugo, of Asti, Alexandria, showed shawls made of this byssus. At the London Exhibition in 1862, V. Dessi Magnetti, of Cagliari, showed byssus of the Pinna, thread, cravat, and gloves made of it; and Mariann Randacciu, a shawl made of it. For several centuries the tissues made of this fibre have been the object of a considerable commerce in Italy. Calabria and Sicily make very fine stuffs of it, and stockings and gloves made with it have been much in request by reason of their softness and lustre, and because they are very warm. At present, however, they are principally sold to strangers as objects of curiosity. A French distinguished manufacturer, M. Terneaux, has exhibited for many years, among the useful and brilliant products of his vast manufactories, a piece of cloth, soft and light, made entirely of this byssus. The example has not, however, been imitated, possibly from the difficulty of procuring a sufficient quantity of the raw material. If the culture of these curious molluscs could be carried on like oyster culture, the employment of the byssus would attain to some importance. M. Jules Cloquet, of the Institut of France, in presenting to the Acclimatisation Society of Paris, at its meeting in January, 1861, a pair of gloves made of the byssus, offered some remarks on the Pinnas. Lamarck enumerates fifteen species, exclusive of the fossil ones. The principal of these are the *Pinna rudis* and the *Pinna nobilis*. The byssus is not coarse and rare, like that of the mussel, but fine and abundant; the threads are long, compact, lustrous, silky, of a brown, slightly golden colour; unchangeable. At various periods it has been employed in the manufacture of different fabrics, but, unfortunately, it will not take dyes.

The giant clam (*Tridacna gigas*), whose large shells are used as "bénitiers" in Catholic countries, is attached to the rocks by a strong cable or byssus, formed of many

tough threads, but slightly elastic, spun by the animal, or rather cast in a mould, thread by thread, a glutinous fluid being secreted in a long groove or canal formed by the foot, which, in the air, rapidly acquires solidity. When completed, the united threads form this strong anchoring cable, projecting through an opening in the back of the shell, and adhering by the other extremity to the rock so firmly as to resist the agitation of the sea, and is so tough as capable only of being severed by an axe.

Marine silk is also extracted from the egg-cases of the skate (*Raia batis*) and thornback, called vulgarly "fairy purses." The fibrous part of these purses can be separated, and forms a sort of yellow silk, of which samples were shown at the Paris Exhibition of 1867 by a M. Joly, of Rochelle.

These examples serve as an illustration of the curious resources of Nature, which appears equally able to produce a given substance whether from animal or vegetable material.

Insects, &c., as Ornaments.—Much has been done of late years by our naturalists and jewellers to bring into use many neglected natural products of the animal kingdom—beetles' wings, birds' heads, tigers' claws, &c. The colours of many insects, and of humming-birds, &c., are so splendid, and there is so much novelty and beauty in many of the applications, that the effort to preserve and group them in an ornamental form for European decoration may be hailed with satisfaction, as extending the utilisation of comparatively waste products.

The elytra or wing-cases of some brilliant-coloured beetles are made into garlands and ornaments, and used to decorate muslin scarfs and ball-dresses, and jewellers also make them into pretty ornaments set in gold for earrings, necklaces and pendants. There are two kinds of beetles' wings collected in Akyab, used for ornamenting the dress and person, one called Chink Pooric, and the other Thungor Poorie. Of the former we are told 5000 maunds are procurable after the rain, and of the latter 10,000 maunds during the rain, at the price of 6 to 7 rupees the maund of 74 to 82lb. In Cashmere, pieces of fine muslin, embroidered with beetles' wings, sell at from 8*l.* to 10*l.* In Madras, scarfs, embroidered and ornamented with green beetles' wings,

sell at about 24*s*. Garlands are made of them, and ball-dresses and cuffs embroidered with them. A lace dress curiously and elegantly ornamented with beetles' wings or elytra was shown by an Irish exhibitor in the first London Exhibition, 1851. At the India Museum, Whitehall, very many specimens of this kind of work may be seen in peacock feather and kuskus fans, &c.. ornamented with beetles' wings; and at the Dublin International Exhibition of 1865 a white net dress skirt, embroidered with gold and beetles' wings, from Hyderabad, was shown in the India department. The *Pycanum amethystemum* is sometimes set in a brooch in Borneo, as among certain Indian tribes are the *Buprestis chrysis*, the diamond beetle. The wing-cases of that beautiful beetle, *Buprestis vittata*, are occasionally exported from Calcutta to England. They have a bright metallic green lustre, and are employed to ornament baskets, fans, &c., and on muslins, to enrich the embroidery. In the Philippines the beautifully polished green species of *Stephanorena*, and the handsome *Caryphocera*, with large black blotches on the elytra, are also held in high estimation, and are preserved in a dry state as ornaments. Messrs. Guyot and Migneaux, of Paris, obtained a silver medal at the Havre Maritime International Exhibition in 1868 for a charming novelty in flowers, made with beetles and feathers. The insects used are the *Hoplia farinosa* and *Chrysomelides* of Europe, the *Cassides* of Brazil, the *Phanaeus Damon* of Mexico, and the *Buprestis* of the Indian Archipelago. The feathers are obtained from the humming birds, the Lophophores, and other exotic birds of brilliant plumage. Lady Granville has a very handsome suite of rare Brazilian beetle ornaments, in a tiara, necklace and earrings.

At the London Exhibition of 1862, in the Brazilian court, a group of flowers was shown, made entirely from the wings and wing-cases of insects, to which the jurors awarded a prize medal. The leaves were formed from the pale green and gauzy wings of some large fly; the flowers, yellow, blue, and red, from the brilliant wings of butterflies and moths; whilst the iridescent elytras of several kinds of beetle were commingled here and there to enhance the general effect.

The brilliant beetles originally used as ornaments by the Indians, as *Buprestis gigas*, for bracelets in Guiana, and the

pearly *Pachyrhynchus pretiosus* and *scintillans* of the Philippines, the *Entimus imperialis* and *augustus* of Brazil, the *Præpodes regalis*, and others, are now frequently seen in our shops mounted as earrings, necklets, pins, &c.

We find in the southern parts of the New Continent many insects which seem to have been formed chiefly to gratify the eye by their brilliancy of colour; others that, by the metallic reflection which their carapace gives forth in obscurity may rival even the diamond, such, for example, as the beautiful butterflies of the genus *Morpho*, and especially *M. Adonis*, with its large blue wings, and *M. rhetenor*, *cypris*, *menelas*, *anaxabie*, &c., found in Cayenne, Brazil, and Mexico. The price in Europe of specimens of these for parures has often risen to 6*l.* and 10*l.* Others, of smaller size, are sought after by ladies for their coiffures at balls or soirées, owing to their elegant and dazzling colours, as *Chlorippes Lawrencia* and *C. cianophthalini.* A small golden fly, of an extremely brilliant colour, is strung into necklaces by the country people of Chili, and they retain their brilliancy for a long time. One of the prettiest savage ornaments I have seen was a feather crown from Guayaquil, with long pendants of the elytra of the brilliant green beetle *Chrysiophora chrysoclora* overlapping each other.

Among the ornamental green beetles available are —*Sternocera sternicornis*, Linn., of Northern India, large bluish green with white spots; *Sternocera orientalis*, *S. chrysis*, and *S. Cochinchinea*, *Catoxantha Briquetta*, Hope; *Chrysodema elegans*, Fab. (small bluish green, with a bronze tinge); *Chrysocroa Chinensis*, *variabilis*, *ocellata*, *vittata*, &c.; *Callospistra callypyga*, Malaysia; *Chrysodema elegans*, Fab. (small bluish green, with bronze tinge); *Rhomborrhena resplendens*, East Himalayas; *Calosonia francia*, green with a bronze tinge. A species of *Cyphus* has black stripes on blue; the *Lampetis orientalis*, the *Mesomphatea* of Brazil, is a more square beetle, with the wing-cases studded with small spots like pin-holes.

Other instances of the utilisation of waste products of insects might be cited in the quantity of wax we receive obtained from the combs of wild bees in many countries, the honey being mostly used as food; and shellac and lac dye, which have now become such important articles of

commerce that they are no longer wasted in the countries where they are produced.

The forests of Assam—indeed, of most parts of India —furnish an almost unlimited quantity of the insect known as *Coccus lacca*, from which lac dye and shellac are prepared. Stick lac is the lac insect with its resinous covering on the branches of the trees on which it was produced; seed lac is the insect and resin separated from the wood; lac dye is the colouring matter of the insect; shellac is the resin separated by melting and straining.

We imported in 1870, 11,748 cwts. of lac dye, and 14,131 cwts. of shellac. These products of the wild lac insect imported into the United Kingdom, amount in value to more than a quarter of a million sterling.

Kermes is another wild insect product which is collected in Europe and Africa for dyeing scarlet the fez skull-caps so much worn. Lac, cochineal, and the coal-tar dyes, have greatly reduced the value of kermes.

Many of the simple garlands of natural flowers for the head—the ostrich or egret plume—the shell bracelet or necklet—were first used by uncivilised tribes. We improve indeed, upon some of their simple ideas, and perpetuate and spread many species of decoration, which would otherwise soon be lost. The original selection and taste of the aboriginal races have been adopted and improved upon in shell ornaments, whether for brooches, bracelets, or ear-drops; in glittering insects, or the teeth and claws of wild animals.

We have but to visit the shops of some of our eminent naturalists to find ornaments of the most savage origin elaborated into objects of adornment for the person of the fair sex, as well as individuals of the sterner sex, in what should be the most civilised nation of the world. Wild boars' tusks, tigers' fangs and claws, cheetahs' tusks and claws, are made into necklets and earrings, bracelets and brooches, scarf pins, whistles, seal handles, &c., set either in gold or silver. Any thing *outré* finds favour now-a-days. Necklaces of the tusks and teeth of the wild hog or peccary, the jaguar, the cayman and alligator, and of the bynari (a fish), as worn by the Caribisi tribes of the Essequibo and Pomeroon river districts, were shown in the British Guiana court at the Paris Exhibition in 1867.

A pair of Pianoghotto earrings, as worn in the interior of Guiana, would, I fancy, prove too ponderous to become fashionable among European ladies. They are made of the large teeth of the water haas (*Hydrochoerus Capybara*, Desm), and are provided with an ingenious spring to keep them fast in the ear. Teeth seem a favourite species of ornament in widely separated localities. I know a lady, moving in the highest circles of society, who wears a tooth from the head of her dear departed, elaborately set in gold and jewels, as a pendant from the neck. The Indians of Rio Negro wear a girdle of the teeth of the ounce; the Zulus of Natal, necklets of various teeth; and a shark's tooth suspended by a bit of black ribbon from the ear is the favourite ornament of a New Zealand aboriginal belle.

A breast armour of hogs' teeth is worn in the South Sea Islands; and bracelets made of curved boars' tusks, from the same quarter, may be seen in the South Kensington Museum. In the Christy Ethnological Collection there is an armlet made of boars' tusks, which is worn when dancing by men of the Sandwich Islands; also an iron bracelet from Africa, bound round with fibre, to which is attached a large boar's tusk, as a pendant. Necklaces of monkeys' teeth, with the elytra of the *Buprestis* beetle, are common in Guiana. Sharks' teeth are used too for offensive purposes; spears and swords armed with these serrated teeth, and fighting gloves studded with them, are in common use in the Navigator's group and other islands of the Pacific.

Murexide. A useful product from a waste substance that ought not to be passed over without mention, is the splendid colour called Roman purple, or murexide, obtained from guano. Dr. Calvert, in his jury report at the London Exhibition of 1862, thus speaks of it:—

As this colour furnishes one more remarkable instance of the great assistance derived by practical art from the researches of science, I cannot refrain from giving here a short sketch of its history. In 1776, the illustrious Swedish chemist, Scheele, discovered in human urine uric acid. In 1817 Brugnatelli found that nitric acid transformed uric acid into a substance, which he called *erythric acid*, but which was subsequently called by Wöhler and Liebig *alloxan*. In 1818 Dr. Prout found that the latter substance

gave, when in contact with ammonia, a beautiful purple red colour, which he called purpurate of ammonia—the product known by the name of *murexide* since the researches of Liebig and Wöhler, published about 1837. These discoveries remained dormant in the field of pure science until the year 1851, when Dr. Saac observed that when alloxan came into contact with the hand it tinged it red. This led him to infer that alloxan might be employed to dye woollens red, and further experiments convinced him that if woollen cloth were prepared with a salt of tin, passed through a solution of alloxan, and then submitted to a gentle heat, a most beautiful and delicate pink colour resulted. In 1856 MM. Depouilly, Lauth, Meister, Petersen, and Albert Schlumberger, applied it as a dyeing material to silk and wool, and succeeded in obtaining red and purple colours, by mixing the murexide with corrosive sublimate, acetate of soda, and acetic acid. It will naturally be wondered where the supplies of uric acid or murexide could be found to supply such a demand as at one time existed. The production of the colour from uric acid is in itself interesting, but still more so is the fact that chemical investigation has opened up a source of uric acid so unexpected and so extensive as that of Peruvian guano. To extract uric acid from guano, the latter is treated repeatedly with hydrochloric acid until all soluble matters are removed by heat and washing. The insoluble mass, consisting chiefly of sand and uric acid, is carefully treated with nitric acid of specific gravity 1·40. When the action of the acid is completed the mass is treated with warm water, and thrown in a filter. The filtrate, which has a yellowish colour, and contains alloxan, &c., is evaporated carefully to such a degree that, when left to cool, it becomes a brownish-red or violet solid, called by the inventor *carmin de pourpre*.

Feathers are an article the collection of which increases yearly. For a long time overlooked or entirely neglected in many countries, even in France, where they are most extensively looked after and used, fully three-fourths of the people know nothing of their commercial value, and cast them into the dung-heap.

Waste Vegetable Substances.

Nature produces abundantly and spontaneously in various quarters vegetable substances, in leaves, seeds, and nuts, barks, grasses, &c., which were long suffered to go to waste; but more thrift and care have been bestowed upon them of late years, since industrial uses have been found for many of them, and fortunes realised by numbers who have turned their attention towards rendering them articles of commerce. The esparto and bamboo grasses, the baobab, and other fibrous barks for paper-making, and materials for manufacturing uses, such as the rattan, piassaba fibre, Agave, cotton-seed, oil-palm kernels, and others might be cited, which have now become important trade products.

Vegetable materials have, indeed, given more extensive and profitable employment and results in the utilisation of formerly wasted substances, and the recovery of the residues from manufactures, than either animal or mineral products. The enumeration and description of some few of these will prove both interesting and suggestive.

Utilisation of Vegetable Silk Downs.—A very recent industrial application, which is becoming of some importance, is the use of the pappus or silky down, clothing the seeds of several plants, a substance which was for a long time suffered to run to waste. In Holland, at the International Exhibition of Domestic Economy, a few years ago, I had the pleasure, as a juror, of rewarding an extensive economic application of this material, and now it is working its way into commerce in this country, where private firms and companies are turning their attention to it. The Ceiba Down Company of Stockport use it for down quilts, ladies' quilted petticoats, and other stuffing purposes. It may be well to draw attention to what the Society of Arts and others have done in this direction, so as to concentrate the floating information about these various vegetable downs or silky cotton substances.

So far back as 1835, the Society of Arts received two large pieces of cloth made from the down of the simool, or tree-cotton (*Bombax malabaricum*) forwarded by Captain Jenkins from Gowhatty, in Assam, the place of their manufacture. From a report then made on it, it appeared that the fine, short down of the *Bombax* is spun into a large,

loose, slightly-twisted cord or roving, and this is made into cloth by interweaving it with a warp and shoot of common thin cotton thread, in the manner of carpeting. It composes a loose cloth, incapable, probably, of being washed without injury, but warm, very elastic, and light. From the shortness of the staple, and the great elasticity of the fibre, it is not at all probable that it could be worked by the machinery now in use for spinning cotton, but the combination which it exhibits of fineness of fibre, with great elasticity, will no doubt make it rank high as a non-conductor of heat, and therefore fit it for making wadding and for stuffing muffs, and perhaps mattresses. When combined with wool, it might probably form the basis of fabrics of great warmth, lightness, and silky softness. These predictions have been fully realised as the wants of commerce developed themselves.

Very fine collections of silk-cotton of various kinds were shown at the London International Exhibition of 1862, from Jamaica, Dominica, Brazil, the Philippines, and other quarters; and I also exhibited a large and varied series of samples from the capsules of different trees and plants at the London Annual Exhibition of 1872.

In the India Museum will be found silk-cotton of *Bombax malabaricum* from Madras; cloth made entirely of mudar floss (*Calotropis gigantea*); cloth of one part of cotton and four of mudar floss, and cloth of one-half of cotton and one-half of mudar floss from Agra.

In Africa this silky down of the *Bombax* is utilised, for Captain Burton, in his "Lake Region of Central Africa," mentions its being brought daily to the bazaars as a favourite substitute for cotton, being but half the price. The people spend their waste time in spinning yarn of it with the rude implements they have at their command. In Liberia stockings have been made of it, showing the result of African skill in spinning and manufacturing.

The Indians make beautiful fabrics, about the Rio Negro and Amazon, of the down of *Eriodendron Samauma*. At Guayaquil this silky fibre is used to stuff cushions and in manufactures.

The species of *Bombax* are remarkable on account of their capsules, which on bursting display a flocculent

substance, often mistaken by travellers for cotton. This material, being more silky than cotton, has been distinguished by the name of "silk cotton." It differs also in not spinning so well as cotton does. Some difficulty, therefore, has been experienced in making use of this very abundant cotton-like produce. Mr. Williams, of Jubbulpore, succeeded in spinning and weaving some of *B. malabaricum* so as to form a good coverlet. It has lately been made use of extensively for stuffing pillows, muffs, coverlets, and wadding, and could be converted into half-stuff for paper-making, and perhaps for gun-cotton, and as a moxa. The jury of the Exhibition of 1851 suggested that it might advantageously be used, in combination with other substances, not merely for the purposes of upholstery, but even in the manufacture of mixed fabrics for various other uses in the arts.

At one of the Society of Arts Exhibitions, silk cotton was shown among other paper-making materials. It could not be employed, however, extensively for this purpose, on account of its price.

The *Bombax* down, for several years past, has entered into commerce in the Dutch ports, on the Continent, under the name of "kapok," the local name in the Eastern Archipelago. The increased price of horse-hair, feathers, flocks, and other animal substances for upholstery, has caused more inquiry to be directed to vegetable materials; and these silk cotton downs are cheaper by 50 per cent. than animal substances.

The qualities which recommend it to notice are:—

1. Its immunity from attacks by moths and vermin. 2. Its lightness. 3. Its elasticity and softness. 4. Its medium warmth. 5. Its cheapness.

Its price as compared with feathers for a double bed was stated at Amsterdam, in 1869, to be:—

	lbs.	£	s.	d.
Kapok	22	1	1	0
Feathers	35	2	13	6

And as compared with horse-hair for a double mattress:—

	lbs.	£	s.	d.
Kapok	33	1	11	6
Horse-hair	44	3	7	4

The beds being in each case equally well stuffed. Two Dutch houses showed its application at the Amsterdam Exhibition, in 1869; Mr. F. G. Kratzenstein, of Amsterdam, who received a gold medal from the jurors, and Messrs. Klutgen, of Rotterdam.

About five grammes of silk down are obtained from each capsule. By care and attention in carding, the quality of the down for beds is much improved, and it is sold at sixpence per pound. One house alone in Holland imports from the Dutch-India colonies 1,000 to 1,500 bales annually, having found a considerable sale for it in Holland, France, Germany, Belgium, and England. The oily seeds, when separated from the down, sell for about 12*s.* the 100 kilogrammes; the oil extracted from them at 40 to 45 florins per hectolitre; and the oilcake for cattle at 10 florins per 100 kilogrammes.

The silky down of barriguda, called paina, is used in Brazil for filling beds and pillows, and especially that of *Chorisia speciosa* and *C. pecholtiana*. In the province of Parahyba-do-Norte, it is known by the indigenous name of saumama (*Eriodendron Samauma*), and is sold at four to six dollars per arroba. In the province of Maragnon it is called "paina-tyberina." In Venezuela the silk downs are termed Algodon de Seida.

In Porto Rico and Cuba the down from *Eriodendron caribaeum* is used for stuffing pillows, mattresses, &c., and is preferred to feathers or flock. It is called locally "guama."

The capsules of *Bombax malabaricum*, which are ripe in Tahiti in October, weigh 32 grammes, of which the shell forms 15 grammes, the seeds 10, the down 5, and the trophosperms or divisions 2 grammes.

The brownish down of *Ochroma Lagopus*, and that of some of the species of *Bombax*, is said to have been used in hat making, in place of beaver or rabbit furs. The purple down of *B. villosum* is spun and woven into a cloth, of which garments are made and worn by the inhabitants of Mexico.

The old genus *Asclepias* abounds in plants yielding a strong fibre, as the *Calotropis gigantea*, *Asclepias volubilis*, &c. The Syrian dogbane (*Asclepias syriaca*) a native of America and Canada is cultivated as far north as Upper

Silesia. The silk-like down which surrounds the seeds of this plant is not more than an inch or two in length, but it has, nevertheless, been usefully applied and articles of dress manufactured of it, both in France and in Russia.

Madame Marcelin David, of Clamart, in 1872, submitted samples of the fibres of the stem and of the down of *Asclepias syriaca* to the Industrial Society of Mulhouse, suggesting that the silky down might be usefully employed. Dr. Koechlin thereupon published a descriptive note respecting the plant in the *Bulletin* of the Society for January, 1873, p. 32, in which he states there are many species of *Apocynum* in which the fruit is furnished with a similar cottony substance, but only that of Syria or Canada has yet been employed to any extent under the name of silk down. It is received from Alexandria by way of Marseilles. It also bears the name of cotton of Silesia, and is found in the environs of Hirsenberg and Guiffenberg. The down is as fine as silk, and as white as snow, but so short that it cannot be spun. It serves well for stuffing and wadding. It grows spontaneously in the environs of Strasbourg, and is largely cultivated in Silesia and the United States. It resists perfectly the cold of Europe, and lives to twenty years. The separation of the down from the seed is very easy. After obtaining this, the stems are cut down and treated like hemp, and a similar useful fibre is obtained. The flowers are rich in honey, and it is for this purpose it is cultivated in North America and Silesia. The industrial use of the silky down dates back to the last century, for about 1780 a factory was established at Leignitz, in Silesia, which worked it up alone, and mixed with cotton into stockings and gloves. Others also utilised it.

Emile Dollfus ascertained the length of the fibres of this down to be from 0·020m. to 0·025m., formed, like those of cotton, of a flattened tube, but not turned in a screw form, which diminished the value, from the want of felting property. The fibre is very weak. He found it necessary to mix one-fourth part of cotton in order to work it mechanically, and even with this admixture the filaments have a strong inclination to separate and float in the air. The twist and the fabrics lose all their brilliancy, which he attributes to the fracture of the filaments in working.

Mr. Moncton proposed making use of the downy sub-

stance contained in the follicles of the mudar (*Calotropis gigantea*), and indeed had paper made of it alone, and also mixed with two-fifths of the pulp of sunn hemp, such as the natives use for making paper. As the glossy and silky but comparatively short fibre is difficult to spin, a mixture of one-fifth of cotton was used, in order to enable it to be worked. A good wearing cloth, which stands washing and takes a dye, was produced. It is, however, well suited for stuffing pillows or coverlets. Mr. Moncton calculated that its cost would be one rupee a maund (2s. per ¾ cwt.). This silky down of the pod is used by the natives of the Madras Presidency in making a soft cotton-like thread.

This plant grows all over India, and seems to thrive on soils that either reject or destroy everything else. If its cotton could be generally utilised, the waste lands of India might be covered with it, as it requires no culture and no water, and is productive on dry land. It comes to maturity in a year, but is perennial, and when once planted or sown would require no further care; where thickly planted it might be the means of reclaiming poor soils, as the leaves and some of the upper branches rot, while the root and stem remain.

Lana du Bombardiere (*Calotropis gigantea*), was shown in the Portuguese section at the Paris Exhibition in 1867, from the Isle of Santiago, Cape Verdes, and from Angola. It grows spontaneously. If it were cultivated it could be extensively exported. It is used for filling mattresses, and recently it has been made into fabrics, which are very durable mixed with cotton. The price of the raw materials is about 4½*d.* the kilogramme, or, if cleaned, 6½*d.*

In the United States, under the name of silk-weed, the thistle-like down is used for stuffing bedding. Messrs. Thresher and Glenny made a variety of fabrics of a light, soft texture, some well suited as a substitute for flannel, from the silky down of the *Calotropis gigantea*, called yercum. Speaking of the silk cotton of the *Asclepiads*, among others *Calotropis gigantea*, *curassavica*, and *procera*, Mr. H. Carcenac, juror and reporter on Cotton at the Exhibition of 1862, and at Paris in 1867, stated that he had examined, in the department of the French colonies, tissues partly made with this fibre, which, although very fine and smooth, were not suited to form an elastic and resistant thread.

But it eould be employed as tram in a mixed fabrie, whieh would have a silky feel and a brilliant aspeet, resembling handkerehiefs made with the wadding or waste of silk. This substanee is also well fitted for making eounterpanes, whieh would have the double advantage of being light and very warm.

Another vegetable silk, from the aigrettes of Thioek, very fine, downy, and glistening, is aseribed to *Echites suberosa.* From its nature it eannot be spun, but may be employed as a vegetable eider down.

From the West Indian eolonies and Guiana, the silk eottons of *Bombax pentandrum* and *B. Ceiba*, *Ochroma Lagopus*, and that of several speeies of *Asclepias*, together with the vegetable hair of an epiphyte *Tillandsia usneoides*, although as yet not largely used, eould be employed as waddings, downs, and for eounterpanes. From Reunion, a natural eider down, obtained from the "*Massette*" *Typha angustifolia*, was shown, and the silky eottons of several speeies of *Bombax.*

The silk eottony substanee attaehed to the seeds of *Cochlospermum Gossypium* is used in the East Indies for stuffing pillows, eushions, &e., and a similar substanee is found on the seeds of *Cochlospermum tinctoria*, a Central Afriean plant.

Spanish moss, or Sakra hair, a long horsehair-like parasite (*Tillandsia usneoides*), is abundant on trees in different parts of British Guiana; it is also an extensive article of eommeree in New Orleans, being abundant in the Southern States, and is shipped under the name of Spanish moss. After being deprived of its vitality and eutiele, it is used in upholstery as a substitute for horsehair.

About 10,000 bales are shipped annually from New Orleans.

The fibres obtained from this epiphyte found elinging to the trees in the forests about the Mississippi, are largely used in Ameriea by upholsterers for stuffing earriage eushions, mattresses, &e., possessing eonsiderable elasticity. Naturalists also employ it for stuffing birds. Dr. Terry, of Detroit, has made paper from it, and the manufaeture has attraeted considerable attention in Texas, for there is a region of eountry there, extending one hundred miles from the eoast, where an immense quantity ean be obtained. In Trinidad it is used under the name of vegetable hair. In

some places it is called "old man's beard," or *Barba hispanica.* The mode of preparation is thus described in a Florida paper:—"Some of the moss is collected by agents sent out to gather or purchase it, but a portion is bought direct from farmers and others. The price paid is, for green moss, 25 cents the hundred pounds, and for cured moss from 2 dols. 50 cents to 5 dols. the hundred pounds, according to quality. The green moss having been transported to the mills, is placed for decomposition in large wooden tanks, placed beside the river, of which they at present have two, one capable of holding twenty-five tons, and the other ten tons of the green moss. At present they have in their tanks, in process of decomposition, about twenty-five tons. The moss, having been placed in the tanks, is alternately saturated with water, and allowed to heat, by which the decomposition of the outer bark is effected in from six to eight weeks, and the black fibre remaining is then put in the sun to dry. After being thoroughly dried, it is put in the picker and crushed, which picks and loosens it, and removes all foreign substances, such as sand and sticks. The machine has a capacity for cleaning from two to three tons daily. After being cleaned it is neatly baled by a superior eagle press, in packages of from one hundred to one hundred and twenty-five pounds each, with burlaps. The moss is now ready for shipment to the commercial cities of the north, where it is used by upholsterers for every purpose for which curled hair or its substitutes are employed. When we consider the vast amount of curled hair now used, that prices in the New York market generally range from forty to sixty cents per pound, and that this so-called moss, equally applicable to the same purposes, can be supplied at from eight to twelve cents per pound, the immense field open in its pursuit to parties with capital, intelligence, and enterprise, must be plainly apparent. It is yet in its infancy, but its development as one of our industries will tend to subserve the interests of the people and State of Florida."

This moss now sells in the New York market at twelve to sixteen cents per pound. Sometimes in the south it is simply thrown in a heap when collected, with rubbish at the top; the outer bark will soon then rot off, and leave

the hairy fibre inside untouched; it is afterwards spread out to dry, and beaten to clean away the dust into which the bark has changed. A late New Orleans paper states that the export trade in this article is becoming an extensive branch of business. One factory, with a capacity to pick and bale by machinery about 10,000 bales, had received an order for 250 bales to be sent to Hamburgh by steamer.

In the northern provinces of Russia large quantities of alcohol are now made with the mosses and lichens which grow in abundance. This industry originated in Sweden, and spread to Finland. Many large distilleries showed at the Moscow Exhibition spirit thus prepared, which was pronounced excellent by English, French, and German distillers. The manufacture can be worked at 100 per cent. profit.

A large trade is carried on in Pulu fibre in the Sandwich Islands; this consists of the silky hairs found clothing the rhizome and lower portion of the stalk or stipes of some species of *Cibotium*, a tree fern. Although its use for stuffing pillows, &c., has been known from time immemorial, it only dates as an article of trade from 1857, when a small shipment was made. It soon found favour at California, Vancouver's Island, Australia, and even in Europe, and several hundred pounds are now exported annually from Honolulu.

The fern which produces the pulu grows on all the high lands, commencing at an elevation of about 1000 feet, and extending upwards to 4000 feet. In size it frequently attains to fifteen feet in height. Though found more or less on the five principal islands, the trade in it is chiefly confined to the districts of Hilo, Hamakua, and Puna, in Hawaii. Only a small quantity is found on each plant, about two or three ounces, and it takes about four years for a plant to produce this amount.

Owing to the large quantities collected of late years, the article is becoming scarce in the Hilo district, though in the Hamakua and Puna districts large quantities still remain. But as it is farther for the natives to go to obtain it, and as more expense and fatigue are encountered, the cost is gradually advancing, and the probability is that it will continue to increase each year to the extent of a cent

per pound. The number of persons engaged in gathering pulu varies; including men, women, and children, probably from two to three thousand are now dependent on it for a livelihood, receiving generally from five to six cents per pound on delivery. The labour of gathering pulu is very tedious and slow. When picked, it is wet, and has to be laid out to dry on the rocks or on mats. In favourable weather it will dry in a day or two, but generally in the pulu region wet and rainy days prevail, so that frequently the natives do not get their pulu dry after several weeks, often taking it to market in too wet a state. The dealers have constantly to contend with this inclination of the natives to sell wet pulu, as it makes considerable difference in the weight when dry. The facilities for drying, packing, and shipping, are improving every year, and the article now shipped is generally dry and in good order, closely packed in wool bales. The trade is reduced to a system, and though there is no probability of any great increase, it will doubtless continue a staple export.

The silky hairs of *Balantium culcita*, Kaulf, and those of *Dicksonia arborescens*, found in Madeira and the Azores, have long been used for stuffing cushions and mattresses.

A plant passing locally under the name of soap-root—but which I cannot at present identify—is used as a substitute for curled hair in mattresses, and has given rise to a great industry in California. It employs a capital of 50,000 dollars, sixty men with machinery, and an engine of forty horse-power. The value of the product is stated at over 100,000 dollars annually.

In Algeria, the "crin végétal," made from the leaves of the dwarf palm, is also largely prepared and sent to France, twisted and dyed to imitate horsehair.

Under the name of palm wool, there is collected in New South Wales, Western Australia, and other colonies, a downy substance which is used for stuffing mattresses. The plant —erroneously called a palm—is *Zamia spiralis*. From the deep cavity formed by the peculiar growth of the axila of its leaves, which bears outwardly a strong resemblance to the shape of the hothouse pine, wool is got in very great quantities, and of a kind so soft and springy, that the beds which are stuffed with it may vie with French mattresses for their comfortable and somniferous qualities,

especially if the French custom is likewise pursued—of yearly unpicking the beds, and restoring their elasticity by turning over and separating the wool where it may have become matted by use.

Uses of Wild Nuts, Seeds, &c.—The seeds or stones of many fruits, which would apparently seem useless, have very frequently some economic value. In certain parts of Egypt the date stones are boiled to soften them, and the camels and cattle are fed upon them.

In some places the stones are ground to make oil, and with the cake that is left they feed the camels and sheep. This is practised chiefly on the coast of Arabia, in the Persian Gulf, and at Muscat, where they find it a very nourishing food. In Spain the stones are burnt and powdered for dentifrice. The seed of the fruit of *Ceratonia siliqua*, the carob or locust bean, is now extensively used here ground up for cattle food; in Algeria the seeds are roasted as a coffee substitute.

Very little use has been made of horse-chestnuts in this country, though in Turkey they are considered good food for broken-winded horses. They are most used on the Continent—especially in the Rhine districts—for fattening cattle and feeding milch cows. Notwithstanding their asperity, game birds feed voluntarily on them, and sheep get accustomed to eat them. They contain so large a quantity of potash as to be a useful substitute for soap, and on the latter account were formerly employed in the process of bleaching linen. Chestnuts contain a large proportion of starch.

In the process of starch making, the horse-chestnuts, shells and all, are rasped fine by means of proper machinery; the same kind that is used for rasping potatoes in the manufacture of potato-starch. The pulp is then washed with water on sieves; only the meshes of the latter are finer, as the chestnut-starch granules are much finer than those of the potato-starch. After the starch has settled, it is taken out and mixed with water containing a little alum; two ounces of alum are sufficient for 25 gallons of water, containing from 400 to 500 lbs. of starch in suspension. If the starch settles too slowly, four ounces of sulphuric acid are added, just as in the preparation of potato-starch. Sulphurous acid is to be preferred,

for the reason that it accelerates the settling still more. The starch is dried in the usual manner. The remnant in the sieves may be used as an occasional food for cattle, or, with better pecuniary results, after fermentation for the distillation of liquor, as the fermented product contains 6 per cent. of alcohol. The starch obtained is 16 to 17 per cent. of the chestnuts. If it is to be used as food, it must be washed with water containing carbonate of soda, in order to remove all bitterness, and then washed repeatedly with pure water. Such a starch is now manufactured in the south of France, where the horse-chestnut is abundant.

Horse-chestnuts contain—

Water	50
Fecula	18
Gluten	16
Greasy oil	4
Gum, &c.	10
Tannin, saponine, and salts	2
	100

Although the starch is easily obtained from them, the fruit is not grown in sufficient abundance to make it an article of commerce that can be used with advantage.

The dried seeds of the pomegranate are a favourite medicine in the East, and they are there employed as in Spain and some other countries for tanning and preparing the finer kinds of leather. The grains are mingled with wine in the East.

Dried quince seeds are imported and used for their mucilaginous property for making a kind of bandoline, or gummy fixature for the hair.

In times of scarcity poor natives in India will eat the stones or seed of the tamarind. After being washed and soaked for a few hours in water, the dark outer skin comes off; they are then boiled or fried. An oil has also been expressed from them.

Although the olive is the most important produce of Italy, the means generally employed for extracting the oil are very imperfect, and lead to a considerable waste of oil. Until within the last seven years, after the olives had been crushed by the peasants, the husks were abandoned as worthless; but in a few places steam machinery has been

introduced to turn to account the husks hitherto thrown away, and which it is now known represent a considerable portion of the value of the oil crop. The process for extracting the oil from the husks by a "lavatojo" is very simple. The husks are placed in tubs and worked with water by machinery, until the water has carried off all the remaining oily matters which rise to the surface after the water has been allowed to remain still. The husks are then put into a steam press, which squeezes out all the moisture; and, after they have gone through these different processes, the husks are either used in the country for fuel, or sold to Marseilles firms, who pay for them at the rate of about 8*s.* per ton free on board at Oneglia. The oil thus extracted from the husks is called "oleo lavato," and is worth about 40*s.* per cwt.; it is used in the manufacture of soap. Foreign as well as native enterprise is turning its attention to the olive husks, which, as left by the common oil-presses of the country, have hitherto been abandoned or used as fuel by the peasants. A French speculator at Brindisi has, for some time past, been buying them up in large quantities, and shipping them to Marseilles, where, after undergoing a certain chemical process, they are put into a steam press, and yield as much as 20 per cent. of oil. The highest price yet paid for the husks has been about 16*s.* per ton. The Italians themselves seem now disposed to take the matter in hand. A steam press of 22-horse power has, I believe, been lately started at Brindisi to operate upon 70 tons of husks per day; but it scarcely extracts more than 8 per cent. of oil, far below the yield obtained at Marseilles by adopting the chemical process. The husks at Brindisi are washed or soaked in salt water before being pressed.

Considerable discussion took place in the 'Times' some time ago as to whether acorns were suitable for employment as food for cattle, and the evidence adduced certainly favoured a negative view. Dr. Robert Brown, however, tells us that those produced in California by several species of oak form an important article of food. The acorns of California are mostly large, and the trees in general produce abundantly, though in some years there is a great scarcity, and much misery ensues among the poorer natives. The acorns are gathered by the squaws, and are preserved

in various methods. The most common plan is to build a basket with twigs and rushes in an oak-tree, and keep the acorns there. The acorns are prepared for eating by grinding them and boiling them with water into a thick paste, or by baking them into bread. The oven is a hole in the ground about 18 inches cubic. Red hot stones are placed in the bottom, a little dry sand or loam is placed over them, and next comes a layer of dry leaves. The dough or paste is poured into the hole until it is two or three inches deep; then comes another layer of leaves, more sand, red hot stones, and finally earth. At the end of five or six hours the oven has cooled down, and the bread is taken out, an irregular mass, nearly black in colour, not at all agreeable to the eye or to the palate, and mixed with leaves and dirt.

Professor Paolo Mantegazza, lately presented to the Milan Institute of Sciences a loaf of acorn-bread such as is eaten at Baunej, Urzulei, Tolone, and other localities of Ogliastra, in the island of Sardinia. Prepared with the glands of the *Quercus Robur* and *Quercus Suber*, pulverised, it is of a dark chocolate colour, and not disagreeable to the taste, resembling the *patona* of Tuscany made with chestnut flour. The enormous trade which is now carried on in the acorn cups of the *Quercus Ægilops*, brought from Turkey and Greece, and known in commerce as valonia, shows another useful application of a waste product. The imports to this country alone average 30,000 tons per annum, and they are sold to tanners for about 17*l*. per ton. Every part of the oak contains astringent matter, by the introduction of which into the pores of the hide leather is made. Thus oak leaves and oak sawdust have been successfully used for this purpose, the details of which may be found in the early volumes of the 'Transactions of the Society of Arts.'

The acorns of *Quercus pedunculata* serve to nourish and fatten pigs, and are occasionally employed when roasted as a coffee substitute. Alcohol can be extracted from them, as from all starchy substances. Mr. F. Wilkins, writing on the subject, says:—"The most important purpose to which acorns may be applied is the manufacture of starch. Starch is at present principally made from rice, corn, or potatoes: but, if it can be procured from other materials, these will all be available for consumption, and must, therefore, be

considered as so much food saved or gained. The quantity of starch used in the United Kingdom alone, for laundry purposes, must be something considerable. If we assume a quarter of a pound as the minimum used for each one of our 30,000,000 inhabitants annually, this will amount to 7,500,000 lbs., which, at 5*d.* per lb. is worth 156,250*l.* Potatoes contain about 10 per cent. of starch; so that ten times that quantity, nearly 75,000,000 lbs., must be used to produce it. This is so much food practically wasted. If this starch is sufficiently refined to be employed as arrow-root, as well as for laundry purposes, it may then become a useful article of diet; and, owing to the abundance and cheapness of acorns, it would be made much more easily than from any other source. Ripe acorns may generally be bought for less than 1*s.* per bushel, and the process of starch manufacture would be similar to that from corn or potatoes, namely, by grating, steeping, washing, straining, and drying in the usual way. The gallic acid may be neutralised, or extracted for other purposes, such as the manufacture of ink, of which it constitutes the principal element. I would also suggest the practicability of converting acorns into sugar or gum, either for domestic use or for distilling purposes. By this means a great saving would be effected, and the residue might be given to pigs, which are notoriously fond of acorns, and thrive well on them."

Under the name of candle-nuts considerable quantities of the fruit or seeds of several species of *Aleurites* now come into commerce for oil pressing. The kernel yields about 60 per cent. of a good drying oil. The marc or oil-cake is useful for feeding cattle and manure. The nuts have various local names. In China they are called tung, in the French colonies bancoul, in Ceylon, and parts of the East kukui, and in the Pacific islands doodoe.

A quantity of the small wild oil nutmegs (*Myristica sebifera*) have lately been imported, which yield about 26 per cent. of oil, well adapted for soap and candle-making. As they are very abundant in South America, they deserve the attention of business men.

Beech-mast, the seed or fruit of *Fagus sylvatica*, sometimes called buck-mast, from the eagerness with which deer feed on them, serve chiefly to feed swine on now in the forest; but before the general cultivation of cereals they were

like acorns, the food of uncivilised men. Dried and ground into meal they make a wholesome bread, and roasted form a tolerable substitute for coffee. A clear, yellow, inodorous oil is obtained from them; a bushel of beech-mast will produce about a gallon of oil, or the yield may be said to be 12 to 15 per cent. of oil; 28 per cent. has been obtained, but this depends on the ripeness of the seed and the quantity of pressure employed. The oil keeps better than any other, improving by age, and being still of a delicate flavour up to ten or twenty years. In the reign of George I., a petition was presented, praying letters patent for making butter from beech-nuts. A beech-oil company was one of the most noted commercial speculations of Queen Anne's reign.

Dr. Toumon mentions having met with a beech-tree on the banks of the Nive in the Basque country, the trunk of which was 20 feet in circumference, that produced yearly about 400 lb. of seed, and allowing them to yield but a sixth part of oil, this would give 66 lb., a good annual return.

In 1799 a portion of the beech-mast collected in the forest of Compiègne, yielded enough oil to supply more than the general demands. In some of the middle and south-western states of America, before the mast has ripened the swine are turned in herds into the beech-forest, where they remain till the time for slaughtering. The fruit consist of a capsule or *bur*, as it is sometimes called, containing, when perfect, two small sharp-cornered triangular nuts, of a pale reddish-brown colour, and having within each a white kernel of a rich pleasant taste, abounding in a clear, yellow, inodorous oil, which may be obtained by expression, in the same manner as that of the castor-oil seed, cotton seed, &c. The fruit, which, at the early frosts of autumn, fall to the ground by the opening of the capsule, and are usually gathered by children, are deprived of the husks before expressing the oil, and the residue, or oil-cake, is excellent as food for cattle, swine, or poultry. This use of beech-nuts, however, is seldom made in the United States or England, the principal harvesters being swine and turkeys; but in France, and some other parts of Europe, this branch of industry becomes a source of considerable profit to the inhabitants. The oil

when obtained by the cold process, is at first slightly acrid to the taste, but this property is wholly dissipated by keeping a short time, or by boiling with water. At 60° Fahr., it has a specific gravity of 0·9225, and at 29° it becomes solid. One thousand parts of alcohol of 90 per cent., will dissolve four parts of the oil, but it is completely insoluble in water. Its composition is carbon, 79·77; hydrogen, 10·57; and oxygen, 9·12, with a trace of extractive matter, &c., in each 100 parts. Like other expressed oils, it produces *acrolein*, or the hydrated oxide of acryl, by destructive distillation at a high temperature. By treatment with nitric acid it also, like other nut oils, yields *elaidin* or *elaidic acid*, in combination with *oxide of glyceryle*, and in about 103 minutes is, by this process, converted into a bluish green solid. The soap made from this oil is of a dirty gray colour, becoming yellow by exposure to the air, and having a slightly characteristic odour of the oil. It is somewhat greasy and pasty, and for these reasons is less valuable to the soap-maker than many other kinds of vegetable oils, though in France it is extensively used for this purpose. 3 lbs. of the oil will make 5¼ lbs. of soap, as taken from the frame, which, in two or three months, by drying, will lose a considerable portion of its weight. Beech-nut oil, however, is most valuable for culinary and lighting purposes, for the former of which it is considered very wholesome and palatable, and to a great extent takes the place of butter and lard among the French and German inhabitants of certain districts; when used for lighting it burns well, giving a good light, which is free from smoke. When properly refined, it is good for lubricating delicate machinery, such as clocks, &c., and for the preparation of hair-oils, pomatums, liniments, and ointments; for many other purposes it is not inferior to most of the vegetable fatty oils.

Our Continental neighbours seem to be more shrewd and clever than we are in applying nuts and seeds to purposes of personal decoration; from being cheap, many of these ornaments are despised by our belles, yet none can deny their interest and beauty, and the ingenuity and taste with which they are arranged. The field is an exhaustless one, and many well known ornamental nuts

and seeds of India, China, and South America, have not yet made their appearance in this country to any extent.

The seeds of the shreetaly or talipot palm (*Corypha umbraculifera*) being a species of vegetable ivory, are turned into marbles, beads used by certain sects of Hindoos, button moulds, and various minute articles.

Little bowls and other fancy ornaments are made from them, and when dyed and polished they are easily passed off for coral. These nuts could be obtained in large quantities in Canara, Malabar, and other parts of India; the chief objection to them by the European turner is that they are of such small size. The fruit of the doom-palm is turned into beads for rosaries, and, in Africa, is made into little oval-shaped cases for holding snuff. The speckled albuminous fruit of *Sagus raphia* or *vinifera* are carved into little figures by the African negroes. The nuts of various other palms have some useful applications. The grugru nut (the seed of *Acrocomia sclerocarpa*) is carved into very pretty beads, rings, and other small articles. The hard, black texture of the nut taking a fine polish. The hard nut of the fruit of the dwarf-palm (*Chamærops humilis*) is in Algeria turned to make bracelets and necklaces, which are esteemed for their pretty veining.

The hard stones of the date-plum and other indigenous fruits are frequently elaborately and artistically carved by the Chinese and Japanese, evidencing as in peach, cherry, and other fruit stones in Europe, the patience and skill of the workman who has laboured on them. Under the name of quandung-nuts the spherical seeds of the Australian native peach (*Santalum acuminatum*) are often set and mounted for scarf-pins, bracelets, and other ornaments. In like manner the similar corrugated seeds of *Elæocarpus ganitrus* and other species, cleared of their soft pulp, are used by the Brahmin priests as beads. They are also made into necklaces and bracelets for ladies, which are much admired, especially if gilded or capped with silver mountings. Those of *Monocera tuberculata* are used for a like purpose in Travancore.

The stones of the date have various uses in Africa. The nomad Arabs of the desert, who consume large quantities of dates, crush the stones and mix them with inferior or spoiled dates into balls, which, when dried, are given

to their eamels as food. The stones of certain varieties whieh are larger, such as those of Rosetta and Bourlos, are turned and piereed to form beads for chaplets. They are also largely used as fuel. The Chinese are said to use the ehareoal of a kind of date plum (a jujube) for making their Indian inks.

The seeds of many of the *Cucurbits* have an eeonomic value in some eountries, although in Europe no use is made of them. The natives of India dry the seeds of *Cucumis utilissimus*, and grind them into a meal, whieh they employ as an article of diet; they also express a bland oil from them, whieh they use as food and burn in their lamps. Experience as well as analogy proves these seeds to be highly nourishing, and deserving of a more extensive eulture than is bestowed on them at present. The powder of the toasted seeds mixed with sugar is said to be a powerful diuretie, and servieeable in promoting the passage of sand or gravel in the bladder. Cucumber-seed yields a bland oil, and in Western and Central Africa the seed of some eueurbits furnishes an oil ealled Egusi, largely used for dietetie purposes. Nevertheless, the seeds of some are dangerous.

The seeds of the pumpkin furnish an oil by expression, and are eonsidered in the East a eooling medieine.

What nuts are to the English and olives to the Gauls, water-melon seeds are to the Chinese. The scarlet and yellow melons are in some places grown only for the seed, and are piled up by the sides of the roads for the use of any traveller who will seoop out the seed. Whole junks may be seen on the rivers laden with them. In the loneliest parts you can proeure them when all other food is searee. The 400,000,000 of Chinese all eat them. When friends meet to drink tea or riee-wine, there is always an aceompaniment of water-melon seeds. They are piled up on every dinner-table. They are eaten while travelling in the palanquins. They are pieked out while diseussing bargains. If a workman has a few sapeeks he does just what his child would do—buys water-melon seeds. They are an amusement and a food—as the eigarette is to the Spaniard and the betel-nut to the Hindoo.

The sunflower is a plant whose useful properties have been hitherto too mueh neglected. It has been grown

chiefly as a showy ornamental flower, and the seeds occasionally given to poultry. But in some countries, as in Germany and Russia, large industries have been created out of it. In Russia the export of sunflower-seed oil now reaches upwards of 100,000 cwt., and it is found a useful lubricator for machinery. The residue is used as an oil-cake for fattening cattle, the leaves of the plant for manure, and the stalks yield a valuable potash.

Utilisation of the Seed of Cotton.—The number of seeds found in one boll or capsule varies in different species of cotton from five to twelve. The smooth black seed, principally from Egypt, is that which is most used for pressing oil from, the downy seed resisting the action of the press; but improved machinery has been made to overcome this difficulty. Those who are at all acquainted practically with cotton, know that in some varieties the seeds are free, oblong, black, and without any other pubescence than the long, fine, easily separable, white wool; in others the seeds are free, clothed with finely-adhering greyish down, under the short staple white wool; while, in a third kind, the seeds adhere firmly to each other, so as to form a clustered mass, resembling a kidney, black, and free from every pubescence except the long white wool, which is easily removed.

So far back as 1824 Professor Olmsted called attention in the 'American Journal of Science' (vol. viii. p. 294) to the utilisation of the seed of the cotton-plant. He suggested that, on account of its cheapness, it might be employed in the manufacture of gas in preference to coal, which was then a scarce and expensive article.

"It is well known (he observes) to the inhabitants of the Southern States that, in all the cotton districts, a vast quantity of cotton-seed is annually accumulated, forming a useless and in many instances an offensive and noxious pile around the cotton gins. For this article no important use has been hitherto discovered. Some limited and imperfect attempts have been made to obtain the oil with which it is known to abound; but the absorbent nature of the rind that envelopes the seed, and more especially of the cotton that obstinately adheres to it, after it has passed through the process for cleaning, has proved a great obstacle to the success of this operation. A small quantity

is given to cattle, and a greater quantity is applied to land as a manure. Though it is very fertilising at first, yet on account of its rapid decomposition its powers are speedily lost."

The import of cotton-seed into Great Britain, which a few years ago only reached 80,000 to 100,000 tons annually, in 1871 and 1872 averaged 171,000 tons, valued at 1,500,000*l*., all, with the exception of an insignificant portion coming from Alexandria. It sells in London at 7*l*. 10*s*. per ton, and yields, by crushing, about 19 per cent. of crude oil, almost black, the residuum being cake for cattle food. This oil is refined at an expense of about 5*l*. per ton; and the present value of the refined oil is 29*l*. per ton. It is similar in appearance to refined colza oil. The residue of the crude oil after refining is distilled, and, with care, produces a hard grease or stearine, which commands, when produced of good colour, within 3*s*. or 4*s*. per cwt., the price of St. Petersburg tallow. Even the foots or tarry substance remaining is useful as a paint ingredient. Sometimes the seed is decorticated before being crushed; this process does not alter the nature of the crude oil expressed, although it produces a finer oil-cake, now selling at 7*l*. 10*s*. per ton, being almost free from the black, tough, indigestible husk.

So large has been the export that the cotton-seed oil factories around New Orleans have been compelled to suspend operations for the want of seed. White refined cotton-seed oil has been used principally in America to adulterate lard and sperm oils, but the large hog crop of the last few years sent down the price of lard-oil so low that cotton-seed oil was no longer in demand for purposes of adulteration. The value of the cotton-seed cake used for cattle-food has also been greatly diminished by the decline in Indian corn and other grains.

Various movements have been made of late years toward the utilisation of cotton-seed, formerly considered a burden to the cotton-planter, and in getting rid of which great ingenuity has been expended. The planter seldom took the trouble even of returning it to the land as manure. Lately large establishments have been started in the Southern States for the purpose of obtaining the oil from the seed, the refuse being converted into oil-cake for fat-

tening cattle. The crude oil realises in New York from 35 to 40 cents a gallon, and the oil-cake commands nearly the price of maize, being said to equal it in its fattening qualities. The first mills in America were erected shortly before the late civil war, and the oil, as well as the oil-cake, has yearly increased in public favour. There are at present upwards of twenty mills exclusively engaged in this business, working over 150,000 tons annually of cotton-seed. Of these mills New Orleans numbers six; Memphis, Tenn., four; Vicksburg, Miss., two; Nashville, Tenn., two; Mobile, Ala., one; Selma, Ala., one; and the others at different points on the Mississippi. The aggregate capital of the new Orleans mills is 1,500,000 dollars.

The cotton-seed oil, after being refined, is largely shipped to Bordeaux, Barcelona, and other olive-growing districts in Europe, and, after receiving a certain "doctoring," is re-shipped to America and other countries as "pure olive oil." Cincinnati, Ohio, takes large quantities of the cotton-seed oil, where it is refined and bottled for table use, for which it is well adapted, being brilliant and having a fine flavour.

Some idea of the ultimate value of this branch of industry may be formed from the following facts:—The total production of cotton seed in the South at present is 2,250,000 tons, of which nearly one-third is produced in the valley of the Mississippi. The market price for seed in New Orleans is 12 to 13 dollars per ton, so that the total product of seed is worth some 29,000,000 dollars. From this seed can be manufactured 1,000,000 tons of oil-cake, worth 25,000,000 dollars locally; and 68,000,000 gallons of oil, having a value of 27,000,000 dollars. The ashes of the hulls are worth as fertilizers 3,000,000 dollars. Here is a hitherto waste product which can be sold for 55,000,000 dollars, an amount equal to more than one-fourth of the value of the general crop of cotton.

An American paper states that the yield of cotton-seed from a given number of plants or stated area of ground is commonly about twice the weight of the fibre. Three million bales of 400 pounds each may be taken as the probable annual cotton crop in the future, and this will give a yearly product of 2,400,000,000 pounds of seed. Each pound of this has upon it, say, $\frac{1}{160}$th part of an ounce of

lint or short fibre, making an aggregate of perhaps 36,000,000 pounds of material fit not only for making first-class paper, but also capable of serving as a substitute for ordinary cotton for many purposes. Until very recently, this was all waste, and worse, for the wool on the seed interfered with the planting by machinery.

The short fibrous covering or fuzz left on the seed as it comes from the gin, is usually wasted, albeit of stronger texture than the rags commonly used in paper manufacture. It furthermore serves a very mischievous purpose in cotton tillage, for the reason that it prevents the planting of the seed by machinery well enough adapted for drilling corn and other smooth seeds. None of the cotton-planting devices seem to have overcome the resistance of the flocky covering to the action of the dropping mechanism, and a loss consequently accrues by hand-planting, while, were it not for the reason given, machine-planting might take its place. There is no available datum which would enable us to ascertain the quantity of paper-making material that is now wasted upon the seed and that might be saved; but when the annual yield of cotton-seed is considered, it must evidently be very great. Estimates place the waste at a quarter of a million of tons, but I am not informed of the calculations from which those estimates are derived. The value of the material should be more than that of ordinary paper-stock, as being stronger and better, and for some purposes, as in the production of battings, might be used either as an entire or partial substitute for the ordinary cotton fibre.

Messrs. Rose and Gibson of Earlestown have gone largely into this business of utilising cotton-seed. The merchantable products attained are cake, oil, paper, soap, and the shell, recovered from the paper-making part of the process; this is used instead of buckwheat husk, bran, rice chaff, &c., in the adulteration of linseed and other cakes. The seed as it comes from the gin contains about fifty per cent. of kernel, which yields in the press a third of its weight of oil, and two-thirds oil-cake for cattle food; of the remaining fifty per cent., about a third consists of the short cotton fibre adhering to the husk, and two-thirds of the husk itself. The husks with the adhering fibre can be treated so as to obtain the cotton quito pure for the manu-

facture of paper, to which purpose it is now being applied. Much attention had been paid to the refining the cotton-seed oil, and means have been discovered of removing a resinous constituent that had hitherto impaired its value. The mode of treating the cotton seed at Sankey Mills, Earlestown, is as follows:—The seed, as it comes from America, is first fed in between a pair of rollers running at differential speed and not quite in contact. This cracks the shell or husk, and allows the solid kernel, about the size of a hemp seed, to fall out and be easily separated. A system of riddling further separates a great deal of the dry, broken husk. After this it is boiled in caustic soda in a revolving boiler, by which means much of the remaining husk is got rid of, and final washings so completely liberate the cotton that it is ready for bleaching. Then it is reduced to pulp and converted into paper.

Cotton-seed oil, or the waste from the refining vats, is saponifiable. The soap makers, when they use it, prefer the crude oil. Alone this is said not to make a very good soap; but it is usually the practice to mix one part of the cotton-seed oil with two parts of other fatty substances, by which means a good soap is obtained. The saponification is pursued in the ordinary manner. If much cotton-seed oil is present, the soap will not readily separate from its solution on the addition of salt, but this separation is assisted by the addition of pure water at that stage of the process. The soap thus made is decolourized by boiling over a spent lye containing the carbonate of an alkali.

When (observes the 'Nashville Journal of Commerce') the South was in the full tide of its prosperity, fostered and sustained by cotton, one of the few annoyances of the planter was to get rid of his cotton seed, an article then deemed waste, but after adverse circumstances had rendered necessary the utilisation of every possible resource, one of the first to be noticed and improved was cotton seed, and a brief experience has proved this article to be capable of almost as general and varied uses as the lint. Now, in almost every prominent Southern city there is one or more large factories for converting cotton seed into useful and valuable articles, thus introducing a new industry that brings ample compensation to the producer, employment to a large number of labourers, and many new and desirable

articles for consumers. A brief review of the labour and results of a factory established at Nashville, and known as the Dixie Oil Mills, will be found instructive. The Dixie Mills receive on an average during the season fifty tons of seed per day, for which they pay from 9 to 10 dollars per ton, a very handsome amount to the producer, while for the labour used to manufacture this seed into oil, oil cake, and meal, they pay out over 30,000 dollars per annum. These two items alone indicate the immense benefit arising from the utilisation of this article.

The warehouse, with storage capacity of 3,000 tons, is near the side track, and its platform is on a level with the door of the ordinary freight car. The seed is placed in trucks, which are run on Fairbank's scales, and each load weighed and registered, then thrown into an elevator and carried by endless chain drags to a screen 200 feet distant, where the seed is cleaned, and then passes into a second elevator, which carrics it to three gins in the main mill; these take all the lint off, and prepare the seed for the huller. About twelve pounds of lint per ton is thus obtained. An elevator takes the seed from the gins to the two hullers, which have a capacity of twenty-five to thirty tons per day. From the hullers the seed is carried up by another elevator to the screen which separates the kernels from the hulls, the latter passing into the furnace room, and the kernels between two rollers, which press them flat and prepare them for the heaters, twelve in number. These heaters are iron ovens, five fect in diameter, one foot deep, furnished with an inside revolving set of blades that crumble the kernels into meal, as the steam drives all the water out.

This meal is then put into small bags, which are enclosed in hair mats and placed in the iron boxes of the presses. There are cight largest sizc Callahan presses of six boxes each, worked by two hydraulic pumps, which bestow a pressure of 375 tons to each press. This pressure forces the oil from the meal, lcaving a solid cake about one inch thick, eighteen inches long, and five inches wide, weighing nine pounds. The oil passes down through a filterer into tanks in the basement, five in number, holding 1,500 gallons each.

A ton of seed yiclds thirty to thirty-one gallons of oil,

worth thirty-five to forty cents per gallon at the mill. These oil cakes, of which sixteen to twenty tons are made each day, are either packed whole in bags, or ground into meal ready for use, and placed in bags ready for shipment, and it is worth at the mill 20 dollars per ton.

The natural gravity of the oil is twenty-five, but it can be refined to any gravity, colour, or scent, and being almost perfectly pure vegetable oil, it can be used to adulterate any oil except coal oil. It is very largely used in adulteration of lard, and makes whiter, cleaner lard than the animal oil. Cincinnati and St. Louis use most of their cotton seed oil in the manufacture of stearine. The superintendent of the Dixie Mills took four gallons of refined cotton seed oil, mixed with one gallon of pure olive oil, and got a certificate from one of the most celebrated and critical hotel keepers in the South, testifying to the great excellency of five gallons of *olive oil* tested at his hotel. New York, Boston, and Cincinnati take the principal part of the oil made here.

The meal has almost as great a variety of uses as the oil. Mixed with bones or ashes, it makes a superior manure. It is the very best of food for sheep, and as a food for milch cows it has no superior, often doubling the yield of milk in a short time. Already the leading stock men are using it largely, finding it healthful, valuable, and vastly cheaper than any other food, and when farmers and stock raisers learn its advantages, not an ounce of it will be permitted to go away from the State. As it is, the bulk of the product is sent to the New England States and to Europe, where they learn quickly what is to their advantage. The fact that cotton seed was lately esteemed mere waste makes our American people slow to appreciate its value. In the mean time, they import Northern grain and hay at exorbitant prices, and export their equally valuable product, cotton seed, at very low rates, leaving the Northern producer to make a profit both ways.

Analysis shows the comparative value of oil-cake meal to be as follows:—

1 lb. of oil-cake meal is equal in value to 3 lbs. of Indian corn.

1 lb. of oil-cake meal is equal in value to 9 lbs. of shorts.

1 lb. of oil-cake meal is equal in value to 10 lbs. of hay.

Mr. Robert Somers, in a recent work describing his visit to the Southern States, thus speaks of the various processes for utilising cotton-seed :—"It is first carefully separated from the hull and wool in which it is encased, the latter being gathered up and baled as merchantable cotton. The pure seed is then ground into meal, which is put into little narrow rectangular bags of a strong and peculiar texture. These are next placed in the pigeon-holes of a powerful hydraulic press, which expresses the oil. The bags are then drawn, and their contents are the cotton-seed cake. The oil flows down from the press into tanks, whence it is pumped into an upper storey, and undergoes a regular process of refining. When manure is to be made, the oil-cake is ground by the same stones as grind the seed, and the meal is mixed with bone-dust or other preparations of lime, treated with chemicals, and becomes a 'fertiliser' as good, some say, as Peruvian guano. It is sold to the farmers at fifty to sixty dollars per ton. The oil-cake is also exported in hundreds of tons, chiefly to England, for feeding cattle; and large quantities of cotton seed of the Southern States pass by the mills on the spot to the same destination, where it undergoes a similar process of oil-making. The cotton oil does not seem to have yet established any very legitimate place in commerce, and fluctuates somewhat mysteriously round olive oil and linseed oil. It is believed that cotton-seed oil is beginning to figure largely on our tables under a certain veil as 'first-rate salad oil.' It is a very pure and beautiful oil as refined in the Mobile mill, and there can be no doubt of its nutritious qualities. A good agriculturist must demur to so much valuable material being taken away from the soil with so little chance of its ever returning to it. The manufacturers, of course, afford every facility to planters of exchanging cotton seed for seed-cake and manure, and whether their trade is to be an enduring one or not, there can be no doubt of the valuable lesson they are reading the planters as to the economisation of the materials about them. If the seed-cake with the oil expressed be good for fattening cattle, the seed, with all the oil in it, must be a much richer feed, and go much further in admixture with other stuffs; while it is certain that there is no part of the world where there is so much room for profit-

able stock-feeding as on the cotton plantations of the South. There are little machines, to be bought for 150 or 200 dollars, by which any planter may separate the wool and the hull from the seed, and realise in his own farm-yard nearly all the economical results of these elaborate and extensive oil mills."

The principal machines now largely in use in preparing the seed for grinding in the cotton-seed oil factories of the Southern States, cost about 500 dollars each, are capable each of removing the fibre from ten tons of seed per day of ten hours, and, in their construction, are substantially simple modifications of the saw-gin, the saws being made with very fine teeth. It is satisfactory to know that the short fibre, for so long a time of no value in itself, and a nuisance in the usual use and management of the seed, may now be turned to useful purposes.

In recent years the utilisation of other waste products of the cotton-plant has received much attention, and in some respects has progressed more than new industries are apt to do.

Mr. G. C. Schaeffer drew the attention of the Commissioners of Patents in America, in 1859, to the fibre of the stem of the cotton-plant, at present neglected or destroyed.

" It is well known," he observes, " that in all parts of the world the bast liber or inner bark of the malvaceous plants yields a useful fibre of various degrees of fineness. There was no reason why this should not be true of the cotton-plant, and it seemed rather remarkable that no notice of such an use of its bark had ever been made.

" I made this matter the special subject of examination, and found the cells forming the fibre rather coarse, much more so than those of the species of *Hibiscus* and kindred plants, which in the Sandwich Islands, yield a very fine and durable fibre; still the cells of the cotton-bark fibre may not always be as coarse as in the plants examined by me.

" There is, however, another bar to their being extensively used; the wood of the cotton plant is tolerably hard, and the separation of its fibres by mechanical means is not so easy as in the case of other fibrous plants, such as hemp, in which the wood-cells are short, relatively small in number, and easily separable from each other, and from the bast cells.

"Again. If the plant is left to mature for the purpose of getting the cotton, the bark fibre becomes, by prolonged exposure, so much stained that it cannot be easily bleached, or, at least, not without injury to its strength.

"Still in the present scarcity of paper-making material, it may be well to look to the bark of the cotton plant as a partial supply for the commoner kinds of paper. Fermentation, or any of the known methods of separating the wood, might be employed; except where labour is very cheap, stripping by hand could hardly be thought of as a profitable method."

Within the last year or two the subject has occupied attention in India, and was first brought before the Agricultural and Horticultural Society of India in 1863, by Dr. R. F. Thompson. The fibre and cloth made from it equalled that of jute of low quality. Dr. Thompson states:—"At Dharwar, in the Bombay Presidency, no less than 378,000 acres of land are under cultivation at one time for cotton alone. I find that after the cotton is collected the shrub, which is annually destroyed, yields a good serviceable fibre, sufficiently strong to pack that very cotton. By throwing it away there is an annual loss of 226,000*l.* at the very lowest calculation. The shrub in its manufacture wants steeping.

"I believe the cotton stalks are burnt at the end of the season for manuring the soil. It will not interfere in securing that object after removing the fibre, as the sticks can still be used as fuel. To meet the expense of extracting the fibre, a deduction of one and a half lakh of rupees may be put aside for that purpose, leaving still an immense sum to the credit of the cultivators.

"Within the last ten years the cultivation of cotton in India has increased tenfold, and immense sums are actually wasted in not utilising the stalk fibre.

"The fibre when cleaned has a fine glossy appearance, and I have no hesitation in believing it will readily find favour in Manchester, if properly introduced to the notice of the manufacturers; inasmuch as many valuable fabrics can be manufactured from the fibre."

Few among the minor tendencies of industries are more worthy of note than that shown in the increasing utilisation of waste materials. As competition becomes

sharper, manufacturers have to look more closely to those items which may make the slight difference between profit and loss, and convert useless products into those possessed of commercial value, which is the most apt illustration of Franklin's maxim, that "a penny saved is twopence earned." Our manufacturers have not been slow to appreciate this truth, as is shown in more than one branch of trade. Few would imagine that the refuse fibres from the spindles and looms of cotton-mills would form the basis of a distinct branch of trade; but so it is. Millions of pounds of it are used annually in the fabrication of cloth and wadding, which, when worn out, goes as stock to the paper-mill. It is even the subject of invention, a patent having been taken out for a means of more effectually using the cotton waste in a kind of batting formed simply by sewing a layer of the material between two thicknesses of cotton fabric. The waste is, as is well known, used extensively for cleaning machinery, and when saturated with oil was formerly very commonly thrown away. It is found, however, quite profitable to wash it with soap and water for use over and over again; but doubtless some day some one economically disposed will adopt the plan of cleansing it with bi-sulphide of carbon, from which the oil can be separated and saved. Perhaps this plan might be adopted to advantage in preparing for use the "soiled mop," which is the material used in cotton-mills for wiping the looms, and which, after being cleansed with strong alkalies, is sold for 6*d.* a pound. It is said that 2,000,000 pounds of this "mop," is used annually by the railroads in the United States for cleaning locomotives and similar purposes. Upon so large a quantity the employment of bi-sulphide of carbon, as above suggested, ought to effect a considerable saving, both on the destruction of the material and also in the utilisation of the oil absorbed by it. So much concerning the utilisation of a material that thirty years ago floated by tons down the Merrimack river from the cotton-mills along the stream. There are a hundred opportunities among the staple industries of the country to secure an equal economy and profit, by turning to proper uses substances now disregarded and thrown away as waste.

Oil-cakes.—The various oil-cakes obtained from the oil-mills in the pressure of oil, forming at present extensive

articles of commerce for feeding cattle, for manure, &c., can scarcely be deemed now waste substances, but they are after all but secondary products and residues from more important industries. Greaves, or tallow-cake, is used for feeding dogs; cotton-seed-cake, linseed-cake, cocoa-nut-cake, and others, are employed as food for stock, whilst rape-cake, mustard-seed-cake, and some others serve for manuring land.

At the first London Exhibition in 1851 there was a good show of oil-seed-cakes for manuring fields and feeding cattle, among others there were from Holland cakes from the seed of the *Camelina sativa*, or "Gold of pleasure," hemp and linseed-cakes, poppy-seed-cake, cakes from *Sesamum indicum*, rape-seed, turnsol, or sunflower-seed, beech mast and gourd-seed. Cotton-seed-cake was then shown for the first time as a novelty, and awarded honourable mention by the jurors. In the Jury reports, "the seed is recommended on account of its cheapness, being usually thrown away as refuse by the cotton manufacturers. It is extensively used as a cattle-food, in an unprepared state, in various parts of the tropical world, and to a limited extent in England; but its success is doubtful, and in the shape of oil-cake it has not yet been fully tested." A large number of new oil-cakes have since entered into commerce, among others those of the ground-nut. In China the cakes made from the sesamum-seed and the oil-pea form large articles of commerce.

Among the principal seeds and nuts imported into the United Kingdom for pressing oil from, are the following, taking the return for the year 1871:—

Cotton-seed, poppy-seed, mustard-seed, flax-seed, linseed, rape-seed, ground-nut, and others, 2,062,458 quarters. Some of the flax-seed may be used for sowing, but almost the entire bulk goes to the oil-press. Of foreign oil seed-cake of various kinds we imported, in 1871, 162,804 tons.

Recovery of Oil-residues.—Dr. Hofmann, in his Chemical Jury Report (London Exhibition, 1862), tells us that bisulphide of carbon has been found by M. E. Deiss to be especially useful for recovering the oils retained by the pressure residue of olives, or by the sawdust through which the oils have been filtered to purify them; also for extracting the fatty matter contained in the spongy parts of the joints of beef and mutton bones, &c. M. Deiss has

already established several large factories in which fatty substances are extracted from residual matters by means of bisulphide of carbon, one at Paris, another at Brussels, a third in London. In these works about 8000 kilogrammes (16,500 lbs.) of residues are treated daily, and the quantity of fatty substances diurnally recovered amounts to more than 1300 lbs. The fatty bodies extracted by means of bisulphide of carbon have all the properties of those obtained by mechanical pressure; in some cases, however, they are, according to M. Deiss, somewhat richer in stearine. Thus the oil remaining after repeated pressure in olive oil-cake and extracted by bisulphide of carbon is decidedly richer in stearine than ordinary olive oil, and on that account is particularly adapted for the manufacture of soap. M. Deiss has, as yet, met with some difficulty in disposing of the exhausted oil-cake as manure, but experiments, made on a large scale, have satisfied him that the bisulphide extracted cakes are not less efficacious than ordinary oil-cakes. To show the importance of the extraction of residues of fatty substances, it may be mentioned that according to M. Deiss's estimate the quantity of oil annually lost at Marseilles amounts to nearly 7,000,000 pounds, while in the departments of Calvados and Nord the loss is at least doubly as great.

A process for extracting the residues of oil from cold-pressed oil-cake has lately been brought out in Liverpool. The cakes from which the oil is to be extracted are first reduced to a pulp in a steam-jacketed kettle by the solvent action of dry heat, in combination or not with an acidulated vapour. The pulp is then placed in bags, and is subjected to a graduated pressure. As soon as the first or virgin oil has flowed, the pressure and heat are increased, and a small amount of free steam is also allowed to act on the edges of the bags. The cake remaining after the castor-oil has been expressed is in great demand in parts of Italy as a manure for hemp growers, and is also used for burning.

Mr. J. C. Lee, of Littleborough, Lancashire, patented in March, 1872, some processes for recovering oils and other useful matters from soap-suds and other waste-waters. The soap-suds are treated with the exact amount of acid requisite to liberate the fatty acids in the form of magma. The magma is placed on filters, and is then

treated with acids and alkali, and pressed with the aid of heat, to separate the fatty acids. The fatty acids are distilled in stills lined with a metal or alloy not acted upon by oil, a steam jet or exhauster assisting in the discharge of the vapours. Incondensible gases are discharged by a steam jet. The water remaining is evaporated in a vacuum-pan to a dry residue, from which useful matters may be extracted. Sewage, blood, stale fish, and similar matters may be desiccated in the same way. The cake is decomposed in retorts, to obtain ammonia or carbonate of ammonia.

Glycerine and its Uses.—The water with which palm-oil has been boiled, after treatment with sulphuric acid at a high heat in the process of acidification, was for many years allowed to run to waste. But it is now, and has been for a long time past, an important source of glycerine. The free acid contained in the boiling water is neutralized with lime, and after precipitation of the sulphate of lime the resulting weak and impure solution of glycerine is concentrated, giving the rough glycerine down. This, by further treatment and distillation, furnishes the pure glycerine of commerce.

This formerly waste product is now a commercial commodity in demand for dozens of purposes, and by all classes of society. Glycerine has taken a most important place both in manufactures and domestic economy.

To the firm which trades under the name of "Price's Patent Candle Company," London, we owe the great perfection to which the distillation of glycerides or saponifiable fat is carried, *i. e.* so as to procure intact the glycerine. Indeed, with them arose the birth of chemically pure glycerine.

When Scheele discovered glycerine and Chevreul described its properties, there was no apparent use for it. It has now become one of the most important and useful products of chemical technology. A few years ago it was thrown away; now it is made in great quantities, and the demand for it is largely on the increase. Nitro-glycerine, dynamite, lithofracteur, are among the secondary products of this interesting substance. The uses of glycerine in medicine, for the extraction of perfumes, in confectionery, to keep substances moist, as an antiseptic, for gas-meters,

&c., are a few among the many uses for glycerine. It is converted into soap, and has an emollient and softening influence on the skin.

At a meeting of the Society of Civil Engineers, Paris, M. E. Asselin recommended the use of glycerine to prevent incrustation in steam boilers. Glycerine, soluble in water in every proportion, increases the solubility of combinations of lime, and especially of the sulphate; it appears, besides, to form with these combinations soluble compounds. When the quantity of lime becomes so great that it can no longer be dissolved, nor form with the glycerine soluble combinations, it is deposited in a gelatinous substance, which never adheres to the surface of the iron plates. Moreover, the gelatinous substances thus formed are not carried with the steam into the cylinder of the engine.

M. Asselin advises the employment of 1 lb. of glycerine for every 300 or 400 lb. of coal burnt, fifteen days' supply being introduced at once. From trials made with boilers fed with bad water, it was proved that the glycerine combined with all the salts, and left the plates perfectly clean.

Glycerine is now much used as a substitute for treacle in the making of printers' rollers, as they can be used daily from six to nine months without being re-cast. These rollers only require to be cleaned once or twice a week with oiled waste, and can be re-melted as often as required, without that deterioration and wasteful expense which accompany the use of treacle roller stuff. The glycerine roller can be made for half the money of the patent composition rollers.

More than two million pounds of glycerine are now manufactured in the United States annually, of which Hartmann, Laist and Co., of Cincinnati, make about one-half. The use of glycerine in gas-meters was suggested in 1852, in the laboratory of Dr. John Torrey, at the old Medical College in Crosby Street, but all gas men looked on it as chimerical, glycerine being then little more than a curiosity of the laboratory, and the charging of a meter with it would have cost more than the meter itself.

The products of the Cincinnati firm above named are of three grades; that which is used in meters is, of course, crude, but of excellent quality for a crude article; some-

what coloured, it has little odour, and though said to contain some lime salts, these are scarcely perceptible to the taste. Its density is 25° Baumé, equivalent to a specific gravity of 1210, water being 1000. It is almost perfectly neutral. For charging meters this is mixed usually with an equal volume of water. Meters are in use that have been filled for nine years with this mixture, and still give satisfaction.

In Dresden, glycerine is generally used in place of water in gas-meters; after it has been so used for some time it becomes foul and requires purification. The fluid is first heated for twelve hours to from 50° to 60°, and next from 133° to 150°, in order to eliminate water, ammoniacal compounds, and other volatile impurities; the glycerine is next filtered over granulated animal charcoal. Some 300 to 400 cwt. of glycerine are annually purified in this way at Dresden.

Two other qualities of glycerine are distilled; one of these once, making an article much used by nitro-glycerine makers; the other twice, and suitable for medical purposes and perfumery. This last article is as dense and thick as molasses, as white and clear as distilled water, possessing a pure, intensely sweet, burning taste, absolutely free from every trace of odour when rubbed on the warm hand, and in every way equal to the highly expensive imported products of Trommsdorff, Price, and others. The manufacture is carried on by a peculiar apparatus, the invention of Mr. Laist. It is stated that the manufacture of purified glycerine has increased of late years more rapidly in the United States than in any European State.

Grape Residues.—An oil can be obtained from the seeds of grapes, which in the wine countries is too frequently wasted. In Italy, the Levant, and parts of Germany, the seeds of the grapes have long been utilised for this purpose. The Economic Society of Bern published, as far back as 1782, an interesting memoir on this subject, and a few years previously the Georgic Society of Rome issued an 8vo. pamphlet with illustrations on the same subject. M. Batillal, in the 'Proceedings of the Society of Science and Arts of Macon' for 1813, states that from eight casks of the marc of grapes which he sifted, he obtained two casks of seeds, which yielded him 33 lbs. of oil. In 1824, M. Bouchotte,

a distiller of Clermont-Tonnerre, extracted from 30 lbs. of grape-seeds, 3 quarts of oil, or about 18 per cent., and he found that the marc from which the seeds had been removed yielded on distillation a bitter spirit.

The oil is of a golden yellow aspect, and requires purifying and refining, and thus loses about one-fourth, but the deposit makes a good soap. The oil thus purified furnishes a good burning oil, and is equal to olive, having neither smell nor smoke. A vineyard proprietor who makes 1500 hectolitres of wine can obtain from the seeds about 150 cwt. of oil, and apply the residue for fuel; 60 lbs. of seed will yield from 6 to 10 lbs. of oil; it may thus be seen how much is lost in many of the large vineyards; the marc is available either for distillation or for making verdigris.

The seeds of white grapes are less rich in oil than those of black, and those from old vines yield less. Those from Roussillon, Aude, and Hérault vines give 2 per cent. more oil than those from Bordeaux.

A pleasant wine can be made with the husks of grapes, and a real good marketable one by adding sugar in proportion to the vinous principles. Thus a vintage can be increased from 100 to 200 per cent. without the least detriment to its quality. If the husks are not wanted for this purpose, a good vinegar may be obtained from them. Grape-seeds are very valuable for fining and strengthening the wine. They must be well dried, and kept hung up in an airy place.

The residuum of wine manufacture is used for fuel in Italy, and so are the cakes of rape-seed after the expression of the oil. Crude carbonate of potash is obtained in Italy from incinerated grape skins.

The refuse grapes from the wine manufacture are first buried in a trench, covered with boards, on which stones are laid. After some time the must is taken up and treated with boiling water, which extracts almost all the argol in the must; the press cake is then dried and placed in the retort for gas-making.

The gas evolved is said to give a higher illuminating power than ordinary coal-gas, while the coke, quenched with water, may be used as a coal for filtering, or to prepare "Frankfort black." The water used for quenching

the coke may be evaporated, and from it a good quality of potash obtained. To prepare the "Frankfort black," the coke is treated with cold concentrated hydrochloric acid, and then washed with water. The substances thus dissolved out of it form an exceedingly rich fertilizing material.

Alcohol is obtained in Italy by the distillation of the fruit of the *Arbutus Unedo*, and sold at 8*d*. the kilo, at 40° proof; and it is also made from the *Helianthus tuberosus*.

The beet-root sugar manufacture on the Continent has now made such enormous strides that nearly one million tons are made annually. In the manufacture, two refuse substances are obtained, the expressed grated root, or sugar-cake, and the molasses. The first constitutes hard solid cakes, possessing considerable nutritive properties; it is therefore used with much advantage, along with other food, in the feeding of cattle. The molasses was formerly given to pigs, or used for making a soluble colouring matter, its value not having been appreciated as it deserved. It is now, however, generally applied as the raw material for the distillation of alcohol. When mixed with water slightly acidulated with sulphuric acid, and submitted to fermentation, the molasses will yield about 24 to 30 per cent. of pure spirit. This beet spirit is, I believe, largely used, like potato spirit, to adulterate brandy. In the watery liquid remaining in the stills are found all the salts originally contained in the juice of beet-root. Experience has shown that it repays well the cost attending the evaporation of the water to obtain these salts (almost entirely composed of compounds of potassium) in a dry form.

The washings of the saccharate of barytes are sold to the makers of potash and soda, who make a profit by boiling them down to obtain what salts they contain. From the residue of the molasses after distillation, excellent potash is obtained, in the proportion of one-sixth of the quantity of sugar extracted from the beet. Coarse brown paper and pasteboard are extensively made from the refuse in France.

Thus every particle of the root is converted into a marketable commodity, by which the cost of manufacture is considerably reduced. The proportion of the pulp yielded

is about 20 per cent. of the root, and it is valued at about 1*l.* per cwt. The pulp will keep for months in trenches, which are best lined with brickwork, the pulp being compressed into them by means of a rammer, and then covered with straw and a thick coat of earth. It undergoes a partial fermentation after a period of a few weeks, which only tends to make it more palatable to farm stock. It is fed to cattle, sheep, &c., mixed in various proportions with bran, cut straw, meal, oilcakes, or some other nutritious substance.

Thus, not content with the sugar from the beet, many other products are obtained. Brandy is made from it 50 per cent. cheaper than from wine, for a hectare yields sixteen hectolitres (each of 22 gallons) of brandy. The wine distiller of the south of France is ruined when the "*trois-six*" falls below 60 francs, but the distiller from beet can clear a nett profit of 50 francs. A very good champagne is said to be also made from it, which, if it do not play old gooseberry with those who indulge in it, may perhaps pass muster in quarters where sparkling gooseberry now finds favour. When the juice of the beetroot has been purified by the ordinary process, and a pure solution of sugar and water has been obtained, it is evaporated to a suitable density; after which it is fermented by adding cream of tartar, and the required *bouquet* is given by means of aromatic plants.

Brewers' Refuse.—Besides the fresh barm or yeast sold from breweries in this country, the import of dried yeast from the Continent has reached now an annual value of nearly 350,000*l.*, besides the large consumption there must also be in Europe. 133,741 cwt. of dried yeast were imported into the United Kingdom from the Continent in 1871.

Amidst the many products of breweries and distilleries, draff or dreg, the spent malt or grains has been especially applied to dairy purposes; and cows in large towns receive, according to sanitary reformers, far too large a supply of brewers' refuse, which is believed to be not entirely devoid of exciting properties. But in Scotland "burnt ale," a kind of distillery wash, is a favourite draught for animals kept near distilleries. They greedily eat straw steeped in this mixture, or drink the ale with as much gusto and intemperance as human beings often swallow

stronger beverages. In Edinburgh dreg was produced in one large distillery in such quantities that all the cows in the city and its environs could not consume it, and there remained an enormous surplus which had to be discharged into the waters of Leith. This the modern Athenians protested against as an outrage on their sweet-smelling city. Something had to be done.

Seed-cake had been used by farmers, and it occurred to the proprietors of the distillery that the dreg, as well as oil-seed refuse, might be pressed into a cake. Machinery was accordingly fitted up, dreg-cake was prepared, and now the proprietors realize 60*l.* a week from this formerly waste product, which, although so much despised in Edinburgh, is now sent to the farmers in all parts of Scotland, to be returned in the form of fat cattle, butter, and cheese.

The following is the chemical composition of the spent malt from breweries and distilleries according to the analysis of M. Corenwinder ('Revue de Chimie,' No. 22, Feb. 1872, p. 275):—

	Breweries.	Distilleries.
Water	73·100	91·400
Dextrine, starch, and organic acids ..	15·830	4·465
Cellulose	4·573	0·315
Fatty matters	0·134	0·831
Nitrogenous substances (gluten, albumen)	4·400	2·525
Phosphoric acid, clay, &c.	1·963	0·464
	100·	100·
Nitrogen	0·074	0·404

Brewers' grains is, of all moist food, that most esteemed in the north of France for cattle. It contains the largest portion of the nitrogenous elements of the grain added to a certain quantity of dextrine or starch. These constituent principles afford a nourishment which rapidly fattens when beans, hay, and oil-cake are added. That obtained from distilleries is the grain which has been used in distillation. It is difficult to keep, owing to the great quantity of water which it holds. But the French farmers eagerly seek it at the price of 50 centimes the hectolitre (5*d.* for 2¾ bushels). It is given to cattle mixed with oil-cake and crushed beans. By placing in fresh cisterns, this distillery waste may be kept a short time.

Hitherto grains have been chiefly used for the feeding

of cows in the wet state, but in this way they are sometimes injurious to the animal, and always so more or less to the milk. On being dried, however, they are perfectly wholesome, and by giving 6 lbs. a day of the dry material to the cow, an additional five quarts of milk may be obtained, and an increased quantity of butter. The subject is of some importance, since about seven millions of quarters of grain are annually used in brewing and distilling in the United Kingdom, of which one-third is recoverable.

Desiccated brewers' waste grain is now much used as a food for cattle, horses, sheep, and pigs, it is sold at 5*l.* to 6*l.* per ton, by the Dublin Grains Company.

At the time of the cattle plague brewers were obliged to pay to have their grains taken away. On trying several experiments it was found that there were considerable quantities of carbonaceous and albuminous products in the grains, and it was evident, therefore, that they would be useful for feeding if they could be properly dried, not only for cows, but also for horses, sheep, and pigs. After trying several processes, a machine has been invented by which heated air is driven by a fan into a revolving chamber, consisting of several floats or trays, in which the grains are placed, the whole being either partially or wholly surrounded by a steam jacket, and the result is a product which resists all fermentation, which will keep any length of time, and is readily transported. The same process is now applied to spent hops, which, when dried, are found to make capital litter for horses, and so produce in this way manure more valuable than straw litter, inasmuch as it is more absorbent. Messrs. Allsopp & Sons and others have introduced it, and found the health of their horses was considerably improved in consequence.

Uses for Sawdust, Spent Dyewood and Tan.—The waste made by the sawyer, turner, and wood-worker—wood-dust and shavings of various kinds—have several economic uses. Mahogany, birch, and rosewood sawdusts are used by furriers in cleansing and dressing furs; box dust for cleaning jewellery.

The shavings or refuse in making pencils from the wood of the Virginia or American cedar is used to make the otto of cedar wood, a hundredweight of shavings producing about 28 ounces of the otto.

Besides its employment as a packing material, for use in wine-cellars, ice houses, for sprinkling the floors of tap-rooms, butchers' shops, the arenas of our amphitheatres, riding-schools, &c., there are other applieations for sawdust. It is used by many manufaeturers, as by necdle-makers, and nail and screw-makers. It is employed as a vehicle for conveying ammoniacal liquors from gasworks for the manufacture of sulphate of ammonia.

It will interest the proprietors of saw-mills and carpenters in general to learn that the ingenuity of Parisian cabinet-makers in the Faubourg St. Antoine has found a use for sawdust which raises the value of that commodity far above the worth of solid timber. By a new proeess, combining the hydraulic press and the application of intense heat, these wooden particles are made to re-form themselves into a solid mass, capable of being moulded into any shape, and presenting a brilliant surface, a durability and a beauty of appearance not found in ebony, rosewood, or mahogany. It is known as "bois durci."

The use of sawdust for artificial woodwork seems to promise a success. Alum, glue, and sawdust are kneaded with boiling water into a dough, which is pressed into moulds; when dry, it is hard, and capable of taking a high polish. Similar ornaments of great beauty, and resembling carved wood-work very closely, are being made by pressing veneers between steel or copper dies.

Our forefathers only used sawdust for littering their stables, cow-houses, sheep-pens, piggeries, and poultry-houses, the whole being afterwards mixed together and used as farmyard manure. Sawyers and earpenters mixed it in their dunghills for growing potatoes; while fishermen used it for smoking fish, and mixing it in their ash-pits along with fish refuse, selling the compost to farmers.

The immense saw-mills whieh exist in the United States, Canada, Norway, and Sweden, accumulate a vast quantity of sawdust, which it was long found diffieult to get rid of. Useful applieations, however, have now been found for these mounds.

Mr. Sandholt, of Drammen, in Norway, showed at the Paris Exhibition models of apparatus by which he converts this waste sawdust into commercial products. Instead of having to employ two horses continually to remove the

accumulations of sawdust, he now converts it into spirit, oil, pyroligneous acid, soap, charcoal, potash, &c., of all of which he exhibited specimens at Paris.

In Canada a patent was taken out in October 1872 by J. Kent Griffin, of Waterdown, for a composition for pavements, blocks for buildings, &c., made of sawdust or disintegrated wood fibre, heated with silicate of soda or potash, and combined with asphalt or tar and a hydraulic cement.

But sawdust can be applied to other and even more important purposes in the sustenance of man. To make wood flour in perfection, according to Professor Autenrieth, the wood, after being thoroughly stripped of its bark, is to be sawed transversely into discs of about an inch in diameter. The sawdust is to be saved, and the discs beaten to fibres in a pounding mill. The fibres and sawdust, mixed together, are next to be deprived of everything harsh and bitter which is soluble in water, by boiling them where fuel is abundant, or by subjecting them for a longer time to the action of cold water, which is easily done by enclosing them in a strong sack, which is to be but half filled, and beating the sack with a stick, or treading it with the feet in a rivulet. The whole is then to be completely dried in the sun, or by fire, and repeatedly ground in a flour mill. The ground wood is next baked into small flat cakes, with water, rendered slightly mucilaginous by the addition of some decoction of linseed, mallow stalks and leaves, lime-tree bark, or any other such mucilaginous substance. Marsh mallow roots are preferable, one ounce rendering 18 quarts of water sufficiently mucilaginous, and these serve to form four pounds and a half of wood flour into cakes. These cakes are baked until they are brown on the surface. After this they are broken to pieces, and again ground, until the flour will pass through a fine bolting cloth, and upon the firmness of the flour does its fitness to make bread depend. The flour of a hard wood, like beech, requires the process of baking and grinding to be repeated. Wood flour does not ferment so readily as wheaten flour, but 15 lbs. of birch-wood flour, with 3 lbs. of sour wheat leaven, and 2 lbs. of wheat flour, mixed up with eight measures of new milk, will yield 36 lbs. of very good bread.

Professor Autenrieth tried the nutritious properties of

wood flour in the first instance upon a young dog; afterwards he fed two pigs upon it, and then, taking courage from the success of the experiment, he attacked it himself. His family party, he says, ate it in the form of gruel or soup, dumplings and pancakes, all made with as little of any other ingredient as possible, and found them palatable and quite wholesome. Are we then, instead of looking upon a human being stretched upon a bare plank as the picture of extreme want and wretchedness, to regard him as reposing in the lap of abundance, and consider henceforth the common phrase "bed and board" as compounded of synonymous terms?

The large quantity of dyewoods remaining after the colouring matter has been extracted has hitherto been almost useless. In 1870 we imported 80,000 tons, and France and other countries also import equally large quantities. In France the residue is mixed with tar refuse, and formed into compressed cakes for fuel. I was much struck with the extent of this utilisation of the spent wood at the large factory of Messrs. E. Dubose and Co., of Havre. This firm used to produce about 120 tons of agglomerated wood per month. The product was distinguished by the relatively small quantity of coal-tar (25 to 30 per cent.) which they used, as well as by the low price at which they were able to sell it, as compared with other artificial wood fuel, namely 4*s.* per cwt. at the works. They also produced pyrolignite of iron and wood acids, but have lately given into other hands the utilisation of the waste residues of their manufacture, as it tends to interfere with their principal product.

Until lately, after concentrating the colouring matter from dyewoods, only a few shillings per ton could be obtained for the exhausted wood as a combustible. In most cases it was thrown away like the residues from other manufacturing processes, the number of which wilful wastes, however, are becoming daily less, thanks to the rational applications of applied science. An ingenious practical chemist at Rouen, M. Chaudet, has begun to utilise this waste, and to obtain from those exhausted dyewoods various interesting products of a commercial value. One of the most important is a paper-pulp obtained by separating the encrusting substances. These in their turn, combined

with the chemical agents by which they are extracted, furnish a useful soda-soap, adapted to cotton printing. The different cakes, by the double decomposition of this soda-soap, can be applied in printing fabrics, paper hangings, in oil-painting, and the preparation of mastics for the joints of pipes.

It is also stated that some of these residual deposits resulting from the exhausted Campeachy and fustic woods can be utilised in steam-boilers for preventing calcareous deposits.

These important applications can no doubt be added with profit to the various industries which in the departments of Seine and Seine-Inférieure alone use up daily over 200 tons of dyewoods in condensing the colouring extract. And if these residues are insufficient, the researches of M. Chaudet have led him to discover that the wood of the chesnut and the beech yield almost colourless mordants, preferable to those obtained from the ordinary dyewoods.

The spent bark of our tanneries, submitted to a hydraulic press, might be employed with coal-dust as an economical fuel, and the derivatives by distillation usefully applied.

In many tanyards abroad the spent bark, pressed into cakes and dried by the hydraulic press, is used for fuel for the boiler of the steam-engine, and owing to the high price of coal tan is also coming into use as fuel again in England.

It can be made into charcoal which would hardly require grinding, for it easily pulverises. The coal even is utilised again for steel manufacture, for manure, and for deodorising purposes. Other saleable articles can be obtained from tan. A Mr. Sorberg took out a patent in 1861 for utilising spent bark by making it into charcoal, tar, acetic acid, and gas. In his specification he states that he can obtain 15,000 to 18,000 cubic feet of gas from every ton of tan. This I should imagine to be somewhat exaggerated, but whether correct or not there can be no doubt that this waste can be made a source of profit, instead of expense, to the tanner.

Signor Cantalupi, in his 'Tables and Formula for the Use of Engineers and Architects,' published at Milan, states that from 1250 kilos of fresh oak bark used in the tanyards, 1000 of spent bark may be utilised, and this equals in heating power 800 kilos of wood, or from 270 to 300

kilos of coal. The heating power of spent bark in a perfectly dry state is equal to 3400 heat units, while that usually met with in commerce is only 2400. A steam-engine of 12 horse-power consumed twelve kilos of bark per hour per horse-power. Owing to the difficulty of obtaining wood ashes in sufficient quantity at a reasonable price for use in dissolving bones, the ashes from the spent bark from tanneries has been recommended. It could be produced in considerable quantities, and sold at 20*s.* to 25*s.* a ton. Spent tan is also esteemed by horticulturists for making beds in which to place pots of flowers. About 250,000 tons of bark of various kinds are used annually in the tanneries of the United Kingdom, the waste of which when exhausted has to be utilised in some way.

C. G. Zetterlund has been making some experiments in the distillery at Hulta to make brandy out of shavings. For this purpose, they were boiled in an ordinary kettle under a pressure of 0·116 kilogramme of steam to the square centimetre. There was then put into the kettle: Shavings (pine and fir, very wet), 9 cwt.; sulphuric acid, 1·18 sp. gr., 0·7 cwt.; water, 30·7 cwt.—total, 40·4 cwt.

After boiling eight hours and a half, the mass of shavings contained 3·33 per cent. grape sugar, and after eleven hours' cooking, 4·38 per cent. A greater increase in the quantity of sugar could not be attained. There was obtained in all, from the 40·4 cwt., about 1·77 cwt. of grape sugar, or 19·67 per cent. of the weight of the shavings. The acid was neutralized by lime, so that the cooled mash ready for fermentation contained one half degree of acid, according to Ludersdorff's acid tester. The mash had a temperature of 30° C. when the yeast prepared from 20 lbs. of malt was added. At the end of 96 hours the mash had done fermenting, was then distilled, and yielded 61 quarts of 50 per cent. brandy at + 15°C., perfectly free from all flavour or smell of turpentine, and of a very pure taste.

It is more than probable that the manufacture of brandy from shavings on a large scale would succeed if it were ascertained, by experiment, with how much water the acid must be diluted, and how long it must be boiled, for both of these circumstances exert a great influence over the production of sugar.

If it were possible to convert the whole of the cellulose

in the shavings into sugar, each hundredweight of air-dried shavings would yield about 7 gallons of brandy of 50 per cent. The shavings of the leaf-bearing trees would probably give the best results.

Uses of Cork Waste.—In the manufacture of corks fully one-third of the woody bark is wasted. This arises from irregularities and imperfections in the wood, and the natural wastage in cutting circles out of any plane surface. This wastage has found several uses, among which the principal are filling cushions, horse-collars, mattresses, the spaces between the roof and top ceiling of houses, the sides of frame-houses and buildings for the storage of ice; for making kamptulicon or cork carpets, flooring of bridges, and Spanish-black; while in the cork factories the coarse wastage is used for fuel. The rough outer bark, not fine enough for corks, is sold for floats for fishing-nets.

In America waste cork has lately been used for stuffing horse-collars. The collar, being light in weight, adapts itself to the shape of the animal, as if it was moulded. It is highly elastic, does not chafe or gall the neck; and the cork being a non-conductor, injury from heat is prevented.

One of the many modes suggested of employing waste cork from machine-cutting is for stuffing beds and cushions, patented many years ago by a M. Bachelard. He recommended the cork to be used in the state of sawdust or shreds, instead of in bulk. Any mode of preparing it may be adopted, provided it is in very small fragments. It can be used alone, or combined with wool or horse-hair. If a substratum of the cork be covered with a layer of horse-hair or wool, we have all the smoothness of a horse-hair or wool mattress combined with the lightness and elasticity of cork. When used at sea, such a mattress might be light enough to act as a life-preserver, in case of exigency.

I know of no better, simpler, or more effective life-saving machine than a cork mattress. It is economical, for it forms a part of the regular equipment of every vessel; it is the best, for it is capable of sustaining more people in the water than any cork belt, floating sofa, stool, or other appliance; it is simpler, because it requires no study to use it; and more effective, for its composition is equal in flotative power to half-a-dozen of the ordinary machines. Boats are, in a majority

of instances, stove or swamped in launching; are continually deteriorating, being exposed to all kinds of weather; are unwieldy, and are generally a snare and a delusion in the hour of real danger. A cork mattress is always right side up; it is light, and can be thrown overboard by a child; it never loses its buoyancy; it cannot be stove or swamped; it will ride every wave, and will ordinarily save more people than any kind of "life-saving" machine I am acquainted with.

In the quarter of La Villette, Paris, old corks, among other floating waste, are collected in the Seine, which have to be thoroughly washed and sometimes re-cut before they are sold, when they fetch a few sous per 100.

The quantity of candied or preserved citron peel shipped from Leghorn in a good year amounts to about 5000 boxes of 4 cwt. each, valued at about 120,000*l.*

About 600 tons of candied peel, or rind of the orange, lemon, and citron, are said to be used annually in this country, and it is chiefly made here.

Citrons intended for peel are imported in brine, but oranges and lemons in boxes. All are ripe in December, January, and February; but as it would be inconvenient to preserve so vast a quantity at the same time, the juice is squeezed out, and the collapsed fruit packed in pipes, with salt and water, till wanted. When the time for preserving comes, it is taken from the pipes, and boiled till soft enough to admit of the pulp being scooped out; then the rind is laid in tubs or cisterns, and melted sugar poured over it. Here it lies for three or four weeks; and then the sugar is drained away, and the rind placed on trays in a room constructed for the purpose. It now assumes the name of "dried peel," and is stored away in the original orange and lemon boxes, till wanted for candying.

Orange-peel contains a large quantity of oil, easily obtained by expression, which is used largely in scenting soaps and other perfumery. It might and probably would be found profitable to collect more generally, by purchase or otherwise, the immense quantity of peel now wasted in this country, for be it remembered we import annually oranges and lemons of the value of 650,000*l.*

The orange-peel is collected and sold in some of the

minor theatres, music-halls, circuses, and other places of public resort, where the visitors use a good deal of this fruit, but I believe it finds its way chiefly to the marmalade manufacturers, with the rind of the Seville or bitter orange, which fruit is used for making lemon-juice.

In France much attention has been profitably given to the utilisation of bran, gluten, and artificial or starch gums. Among other uses for the refuse from potato-starch is that for flouring or dusting their kneading troughs, &c., by bakers.

In the manufacture of wheat starch the gluten was long considered a waste product, but it has received a valuable application in calico-printing; being soluble in weak alkali it is used as a substitute for albumen for fixing on muslins the beautiful mauve colour called French purple.

The mass of gluten which forms a layer on the top of the starch, called "slimes," or "flummery," was formerly used for feeding pigs, but is now employed by calico printers in their "resist-pastes," and by the patent gum manufacturers in the preparation of certain of their products. The gluten obtained has been turned to good account by several manufacturers, who dry it, pulverise it, and sell it as a granulated gluten, and often under the fictitious name of semolina. M. Emile Martin, of Grenoble, received at the Paris Exhibition of 1867 a great gold medal for the improvements he had carried out in utilising the residues of starch manufacture, to the extent of 60 per cent. for cattle-feeding and other purposes.

In its fresh or wet state the gluten from flour forms about 33 per cent. of the flour operated on. In this state it cannot be used in bread-making, its natural tenacity resisting all efforts to make a good loaf. Exposed to the air it dries very quickly, and is converted into a brown, hard, and horny mass. The interior passes rapidly into putrefaction when the quantity is large. But in contact with pure water (such as spring and river water) it keeps well. In water of a very low temperature, and especially in ice and snow, it continues long intact, with the same physical qualities. But following the temperature of the water it changes its chemical properties, and the baker who wishes to use it has to note these changes. The mixture

of gluten with flour forms an excellent bread, which in appearance, flavour, and nutritive value far surpasses bread made with the best flour alone.

The porosity of this bread is remarkable. Gluten bread has been introduced for sale in some of our shops. The transport of gluten is very simple. As it does not adhere to leather, it is easy to send it in cases lined with sheep-skins. A small quantity of fresh water, ice, or snow should be added. The means of giving great nutriment to bread are furnished by this mixture of gluten to flour when it can be obtained.

In the manufacture of potato-starch, the pulp or parenchyma and the water with which it has been washed constitute residues which can be utilised.

The pulp left varies according to the quantity of starch obtained from the potato, but what is usually estimated is 75 to 85 per cent. of its total weight, and 15 or 20 per cent. of wet pulp represents about 4 or 5 in the dry state, of which 3 parts will be fecula and 2 parts woody fibre, not nutritive. The water is composed of various vegetable substances, albuminous, extractive acid, and saline.

On the farm the pulp is given in its wet state to calves, cattle, horses, asses, mules, and pigs, but mixed with oatmeal, hay, and pulped roots. This mixture, seasoned with salt, is greedily eaten, and they grow in health and flesh on it, while the coat becomes more glossy.

Pressed and dried in the air or in a furnace, and reduced to a kind of coarse flour, it becomes a substantial reserve where the granaries and the forage are deficient. In its wet state the pulp is a good fertiliser; and in fields and pastures the water separated from the potato and in the process of washing out the starch is a beneficial application, improving the soil. A potato-starch manufacturer, near Versailles, obtained from his residue a vegetable poudrette which, in its results as a manure, was comparable at 40 per cent. of its weight to the poudrette of Montfaucon.

M. Payen, in one of his works—'Industrial Chemistry'—thus speaks of the profits realised by this operation.

In three months of manufacture there were operated on 17,400 hectolitres of potatoes, and the following refuse materials were obtained formerly wasted :—

		Francs.
82,000 hectolitres of washing water, applied to manuring 16 hectares of land, representing a value of		462
Over 1,100 hectolitres of deposit or vegetable poudrette, 820 hectolitres at 2 francs		1640
Value of the manure		2102
	Francs.	
Cost of trenches for irrigation	210	440
Drying the deposit	230	
Profit		1662

This profit replaces an expense of some 400 or 500 francs actual loss in getting rid of the supernatant water, or in place of damage to streams, equivalent to an annual difference of some 2000 francs' profit to the intelligent manufacturer. The pulp, mixed with two parts of barley meal, field beans, peas, or oatmeal dried, makes a savoury cake for cattle, which may be kept fresh a long time.

Well pressed and steeped in its weight of boiling water, cooled at 30° or 35° temperature, adding yeast and an equal weight of wheat flour, a good household bread is obtained from it.

It also serves to make common cardboard, tobacco boxes, turf for burning, either by simple compression or by mixing with an equal portion of sawdust, coaldust, cinders, or clay.

In distilleries the potato water can be used as a leaven or yeast with saccharine substances. Fermented to sourness, and acidified with the yeast of beer, it serves to oxidise copper plates in making verdigris.

Employed in the boiling state, it gives to linen and cotton goods a grey colour, which is durable on washing with soap. It is also useful for cleaning tissues of cotton wool and silk, used cold.

The husks of buckwheat are much used as a packing material, and in particular constructed stoves for fuel. A patent for such a stove was taken out on the continent a few years ago. The bran, or exterior husk of wheat, in the process of grinding and bolting for flour, has commercial uses in tanning, in calico printing, for stuffing dolls, filling cushions, &c.

M. Milton has communicated to the French Academy of Sciences the result of some interesting investigations of his,

concerning the ligneous matter of wheat, whence it would appear that bran is a very nutritious substance. Though bran doubtless contains from 5 to 6 per cent. more ligneous substances than flour, it presents more nitrogenous matter, twice as much fatty matter, and, moreover, two distinct aromatic principles, one of which possesses the fragrance of honey ; and these are both wanting in flour.

M. Milton therefore thinks that bran and meal ought to be ground over again and mixed with the pure flour, and he has found, by repeated experiments, that this mixture yields a superior kind of bread. Horses that consume a fair allowance of bran usually enjoy better health than those deprived of it.

The saturated bran used by tin-makers, which usually contains from 20 to 25 per cent. of palm-oil, is now utilised by the new application of a process hitherto successfully applied in extracting oil from seeds. It is immersed in benzine for the oil to be brought into solution. The liquid solution is then placed in a still, and the benzine distilled off. The oil derived from the bran remaining in the still will then be ready for future use.

The refuse obtained in cleaning paddy or rice for sale consists of the silicious husks and external layers of rice with broken grains and more or less dust. The outer covering, or husky substance, which is impervious to water, forms a useful litter for stables, and material for packing crockery ware or ice, instead of sawdust.

Rice dust is a most excellent food for horses, milch cows, pigs, and poultry. It contains as much fatty substance as the best oats, and is inferior in this respect only to Indian corn, which is rather richer in oil. Hence, according to Dr. Voelcker, one reason why this refuse is well adapted to the laying on of fat upon animals. Rice dust contains nearly half its weight of woody fibre, which possesses little or no value as a feeding substance. When it can be obtained at a price not exceeding 3*l.* per ton, it will be found a valuable article of cattle food. Under the name of *shude* it is largely supplied to oilcrushers, to mix with oil cake.

Great use is made in France of various waste substances for lighting fires, such as the cones of pine trees. The Société des Allumettes Landaises, of Paris, does a large

trade in the sale of waste cobs of maize, or Indian corn. These are first steeped in hot water containing 2 per cent. of saltpetre, and, after being dried at a high temperature, are saturated with 50 per cent. of resinous matter. These lighters, which are sold at from 10*s.* to 16*s.* the thousand, are employed with advantage and economy in private houses and for lighting furnaces.

By others the cobs are immersed in a mixture of sixty parts of melted rosin and forty parts of tar, after which they are taken out and allowed to dry. They are then subjected to a second operation, which consists in spreading them out on a metallic plate heated to 212° Fahr. They are finally assorted, according to size, and tied up in bundles. These are sold at the rate of three or four for a halfpenny. The establishment in Paris for manufacturing them employs thirty workmen, and effects sales to the amount of 8000*l.* annually.

Every one is familiar with the pretty, lovely looking, white-flowered asphodel of our gardens. In the south of Europe, and apparently on both sides of the basin of the Mediterranean, the plant (*Asphodelus racemosus*) is extremely abundant; in times of scarcity its acrid fasciculated roots, after much boiling, have been eaten by the poor. In the Paris Exhibition of 1855, there were shown bottles of alcohol extracted from the asphodel; specimens of the residuum of the roots after being twice distilled; paper-stuff from the stalks and leaves of asphodel—card-paper, cards, paper, and writing-papers of various quality, manufactured from the same, and mixed in various proportions with rags and common paper-stuff. M. de la Bertoche, in a pamphlet, asserts that asphodel roots contain upwards of 27 per cent. of alcoholic principle, or more than double the quantity which resides in the root of beet. The stalks and leaves contain a remarkably tenacious fibre, fine, strong, and flexible. The distillation of asphodel root has been already pursued, and with considerable success, in Algeria; but the immense abundance of the plant in Tuscany, where it has hitherto been considered only a pernicious and most ineradicable weed, points to the advantage of endeavouring to turn it to account. At the Exhibition of 1862, alcohol was shown in the Italian collection made in Cagliari from the *Asphodelus albus.* The roots, after cleansing and crush-

ing, are mixed with water, and the fluid is exposed to heat, so as to facilitate fermentation. The alcohol which it yields is pure and colourless, perfectly transparent, and has the colour of alcohol itself. It contains neither acid, salt, nor oily matter. It burns without leaving any residue, and the flame is remarkably bright. But, at the present time, when material for paper seems likely to fail, a most important succedaneum is afforded by the remains of asphodel. It is undeniable that the residuum of the roots after distillation, together with the other parts of the plant, is eminently adapted to this object.

The expense of obtaining the foliage and stalks is no more than that of mowing them. Three processes are necessary; the separation of the useful portions, the bleaching, and the reducing the substances into a homogeneous and tenaceous pulp. The first is better effected by crushing than by grinding, as the latter mode is apt to destroy the fibre. The second operation involves most difficulty, as the root is covered with a skin which contains a tanning principle; and it is necessary, unless the expensive mode of hand-picking the root be adopted, to expose the substance to air and light, aided by immersion in dilute chlorine, which brings the substance to a very pale brown tint, which is not objectionable for many sorts of paper. For the third process, that of reducing the whole mass to a smooth and tenacious paste, the paper manufacturers are fully capable.

Amadou.—Among waste spongy, cellular matters entering into commerce, amadou forms one, the best samples of which come from Italy, Austria, and Würtemberg. Before the manufacture of chemical friction matches, the consumption of this substance in France alone reached the value of 24,000*l.* a year; now, its use for German tinder, or lighting purposes, does not there much exceed 3000*l.* or 4000*l.* a year, and its employment in surgery is about one-third that amount. Possibly this reduction in the consumption led an exhibitor at Paris to show caps and articles of clothing made of amadou. Unless endeavours are made to render this substance incombustible, that is to give it properties entirely opposite to those for which it has been hitherto sought, there would not be much success for this industry. It may, however, be incidentally noticed that the inhabi-

tants of Franconia have long known the way to prepare amadou like chamois leather, so as to make warm garments of it. Amadou is nothing else but the spongy tissue of certain fungi, which grow principally on the oak, and also on the horse-chestnut, the poplar, the pear, and the willow. The amadou fungus (*Boletus* or *Polyporus igniarius*) is the most employed. It is collected in many of the central departments of France, in Italy, in Germany, and Austria. It is especially in the department of Gironde, where its preparation is carried on on a large scale. The combustibility of the substance is increased by the addition of saltpetre. The agaric of Sologne (*Boletus Soloniensis*) is used to make the amadou which is sold in Orleans. Besides its use as a styptic, it has also been made into razor strops. The fungus is perennial, and increases yearly in size. The soft, spongy, brown, leathery-looking substance of the fungus, after removing the outer covering, is cut into thin slices and beaten with a mallet to soften it. In this state it is used for stopping hæmorrhages, and for other surgical purposes; and by subsequent boiling in a strong solution of saltpetre it is prepared for use as tinder, constituting the German tinder of the shops. To render it very inflammable, it is sometimes imbued with gunpowder, which gives it a darker colour. On the Continent, before the use of congreve lights and other friction matches, tobacco smokers were accustomed to carry about with them a box containing a little amadou, and a small flint and steel. Amadou is also made with the fungus (*Bovista gigantea*) vulgarly called "vesce de loup." White amadou is obtained from the *Dementium giganteum*. The fungus vulgarly known as the currycomb (*Agaricus labyrinthiformis*), which is used in Italy like a sponge, also furnishes amadou. The substances which may be used as substitutes for the amadou of fungi for different purposes are very numerous. In Italy they employ for this purpose the leaves of *Atractylis acaulis*, Desf.; in Sicily, the vascular tissue of the centre of the stem of *Ferula glauca;* in Spain, the flower of *Echinops strigosus*, or the down and leaves of *Onopordon Acanthium;* in Peru, a down prepared with the young shoots of *Andromachia igniaria.* The amadou of Panama, which serves like ordinary amadou for staunching the blood, is made with the leaves of *Conostigia holosericea*, which is also found

in Jamaica. In India they make amadou with the bunch of male flowers of the bread fruit (*Artocarpus incisa*). The down which encircles the stem of *Calotropis procera* serves for amadou and for stuffing mattresses. In Africa they prepare a species of amadou from the sheath of the stem of the *Musa violacea*, and in Western Africa, with the hairy nodosities which are found on the stems of *Artemisia Hispanica.* The velvety leaves of *Hermas gigantea* are fit for the same purpose, and also serve for tissues, such as stockings and gloves. Under the coarse fibres which cover the trunk of *Arenga saccharifera* are found others of a finer kind, which are used for caulking vessels, and in China are much used as a species of amadou. Finally, in Mexico, they employ for the purposes of amadou the medullary tissue which abounds in the flower stem of *Agave vivipara.*

A species of tinder, called "noli," is obtained in Malacca by scraping the base of palm-leaves, and is used by the natives for firing their matchlocks. They also kindle fire with a fibrous cotton obtained from the *Elais melanococco.*

Thus, for cellular and spongy matters, as for all other vegetable substances, nature furnishes unlimitable resources. Industry is only embarrassed by the choice of raw materials. What is chiefly wanted is the science and knowledge by which we may draw forth and utilise the most suitable of the vegetable wealth which is spread over the globe with such prodigality.

The Economic Uses of Leaves.—Setting aside many of the most important leaves of cultivated plants which furnish great staples of commerce, like tobacco, tea, indigo, senna, &c., there are many minor local uses of leaves which deserve some notice.

The leaves of many trees furnish occasional fodder for cattle—especially several of the Mimosæ in India, Australia, and the Cape Colony. From others an essential oil is distilled, as from the orange, cinnamon, and lemon grass.

From the dried leaves of the *Cannabis sativa* an intoxicating drug is produced in India, and they are also smoked to cause the same effect. They have been imported into this country under the name of "guaza."

The leaves of coltsfoot (*Tussilago Farfar*) have long been smoked for chest complaints, and are said to form the chief ingredient in British herb tobacco. The leaves of milfoil or yarrow (*Achillea Millefolium*), another plant equally

common with the last, have been recommended to smokers in lieu of tobacco, and are occasionally used for that purpose. The leaves of rhubarb are sometimes smoked by those who are too poor to furnish themselves with a regular supply of tobacco, and those who have used them state that, although devoid of strength, they are not a bad substitute when tobacco is not to be obtained. For the same purposes they are collected and used in Thibet and on the slopes of the Himalayas.

The leaves of the bog bean (*Menyanthes trifoliata*) are used in the north of Europe when hops are scarce, to give a bitter flavour to beer, and have been also adopted as a tobacco substitute.

The Virginia or stag's horn sumach (*Rhus typhina*) supplies leaves which are dried and used by some of the native American tribes for smoking. The Indians of the Mississippi and the Missouri use the leaves of another sumach (*Rhus copallina*), and Indian tobacco (*Lobelia inflata*), supposed to be indebted for its name to the fact that it was one of the plants smoked by the Indians instead of the genuine "weed." Under the name of "tomboki" the leaf of a species of Lobelia is smoked in parts of Asia. Beet leaves have been lately recommended as a tobacco substitute in France. The leaves of the Australian Eucalypti have come largely into use in medicine in Europe, and they have been even recommended for cigars.

The leaves of the betel pepper vine are in extensive use in Asia with the betel nut. In the markets incredible quantities of the leaves are offered for sale in piles carried about in baskets. The betel leaf is a powerful stimulant to the salivary glands and digestive organs, and diminishes the perspiration of the skin.

In Peru and Bolivia an important trade is carried on in the leaves of the coca, which is considered stimulant and tonic. Large heaps of the freshly-dried leaves, particularly while the warm rays of the sun are upon them, diffuse a very strong smell, resembling that of hay in which there is a quantity of milfoil. Birch leaves were formerly used internally and externally in cases of dropsy. They are employed at the present day in Finland for tea. A large trade is carried on in South America in the roasted leaves of some species of Ilex, which are used for a tea infusion.

Palm-leaf hats are common in many countries. Palmetto is a common name for several small palms. One species is much utilised in Bermuda, where the leaves are worked into baskets, table-mats, hats, bonnets, and other articles. The palmetto is about sixteen inches long, and is used in bed like a fly-flapper, much to the discomfiture of that little insidious insect, the mosquito. The Bermudians make them with painted and decorated handles, and few towns in the islands are without them.

The fan-shaped leaves of the stately Corypha palm (*Corypha Australis*) are eagerly collected for the manufacture of the well-known cabbage-tree hats of Australia, which, if not so fine as the Panama hats, are equally strong and serviceable.

The Panama hats, so much appreciated and generally worn in Central America, the Southern States, and New Granada, are plaited from the leaves stripped from the *Carludovica palmata* in Peru and the Isthmus States. They are distinguished from all other straw hats by consisting of only a single piece, and by their lightness and flexibility. They may be rolled up and put in the pocket without injury, and can be washed and bleached repeatedly. According to the quality and fineness of the hats, more or less time is occupied in their completion; the coarser ones may be finished in two or three days, the finest take as many months to plait. Some have been sold as high as 20*l.* and 30*l.* each.

The leaves of the dwarf fan palm (*Chamærops humilis*) are used in Algeria for making brooms, seats of chairs, hats, thatch for cottages, &c. The leaves of another class of short palms, the *Thrinax*, have many economic uses. Bundles of the leaves, weighing about one cwt., are imported into Liverpool from Cuba to the extent of more than 600 tons per annum, and are used by the hat manufacturers at St. Albans. *T. argentea* furnishes this chip which is woven into hats, and made into baskets and wicker-work; while other species of the genus supply the palmetto thatch, which forms an article of export from North America. The leaves of *Borassus flabelliformis* are used for writing on, for thatching houses, and making baskets, mats, umbrellas, and fans. Strong and durable fibres are produced from the petioles of the fronds. A fine downy substance is found

at the base of the leaves, used for stopping bleeding wounds.

The leaves of the Palmyra and Talipot palms are made into umbrellas, baskets, &c., but they furnish no useful fibre. Palmyra mats are used for packing betel nuts in. In Tinnivelly, from a single Palmyra leaf, buckets are made, which are used for drawing water from wells.

A flexible integument of the leaf of the Areca palm is used for numerous purposes, and especially for making a kind of shelter or covering to protect the blossom of the tree from the rain. The tying on of these caps is one of the chief expenses incurred in this cultivation. It is also made into sooparee caps, which are worn by the Bunts, an agricultural class of Hindoos in the district of Canara, and into coverlets.

The fibre of the lower end of the leaf of the bynee (*Caryota urens*) is of remarkable strength, and applied to many purposes, especially for fishing-lines. In England it is termed India gut. Lately it has been largely introduced as Kittool fibre from Ceylon, and used for brush-making.

Under the name of "nipah," or "atep," the leaves of the *Nipa fruticans* are used very generally in the far East for thatching.

Of the leaves of the date palm (*Phœnix dactylifera*), brooms and brushes are made in Egypt. Of the fibre ("lif," or "loof") by which the petioles are bound together, all sorts of cordage are made; and it is used as a flesh rubber in the baths.

Mats, baskets, and plates, are made by the Nubian women of the leaves of the Doum palm (*Hyphaene crucifera*). Palm-leaf mats are also made at Tripoli and other places. Mats are made of date leaf in Madras, of the fragrant screw pine, and the pandanus leaf.

In Ceylon, many of the indigenous inhabitants, as well as natives of Europe, thatch their houses with cocoa-nut leaves, by the Singalese called "palattu," and sometimes "cadjans."

The leaves of many of the palms are employed for thatching and making fans; they do not undergo any preparation; a better description of mats for packing purposes might be made, and, if kept always on hand, would probably find a sale.

The leaf-stalks of the palms are harsh, stiff, and brittle, but if beaten and washed, they become softer and whiter; if carefully split and drawn like wire through perforated steel plates, a neat, clean, and durable basket-work might be made from them, and they would be useful for brush-making.

Palm leaves, and perhaps the leaves of trees that do not belong to this natural class, were much used by the ancients as writing materials: hence the word *leaf* (of a book) is synonymous with that of a tree.

The large, broad fronds of the well-known fan palm of Ceylon (*Corypha umbraculifera*) are used for thatching, and also for writing on with an iron style. Such records are said to resist the ravages of time. The dried leaf is very strong, and is commonly used for umbrellas by all classes. It opens and shuts like a lady's fan, and is remarkably light.

The leaves of *Sabal Mexicana*, Mart., are used for making hats and mats, the dried leaves used for plaiting being called "petates." They are prepared for plaiting by being dried and bleached in the sun, and then reduced to narrow shreds. The leaves of *Corypha inermis* are devoted to the same purpose.

An entire leaf of the *Mauritia flexuosa*, a Brazilian palm, is a load for a man. The unopened leaves form a thick, pointed column. This is cut down, and, by a little shaking, the tender segments fall apart; each one is skilfully stripped of its outer covering, a thin, ribbon-like pellicle, of a pale yellow colour, which shrivels up almost into a thread; these are then tied in bundles and dried, and are afterwards twisted, by rolling on the breast, as though into string, or with the fingers into thicker cords. The article most commonly made from it is the "rede," or netted hammock, the almost universal bed of the native tribes of the Amazon. This is formed by doubling the string over two rods, or poles, about six or seven feet apart, till there are forty or fifty parallel threads, which are then secured, at intervals of about a foot, by cross strings, twisted and tied on to a very longitudinal one; a strong cord is then passed through the loop formed by all the strings brought together at each end, by which the hammock is hung up a few feet from the ground; and in this open cot the naked

Indian sleeps besides his fire as comfortably as we do in our beds of down. Other tribes twist the strings together in a complicated manner, so that the hammock is more elastic; and the Brazilians have introduced a variety of improvements, by using a kind of knitting-needle, producing a close kind of web, or by a large wooden frame with rollers, in which they weave in a rude manner with a woof and weft, as in a regular loom. They also dye the string of many brilliant colours, which they work in symmetrical patterns, making the "redes," or "maqueiras," as they are called, among the gayest articles of furniture to be seen in a Brazilian house on the Amazon.

The women of the island of Mahe, one of the Seychelles group, work largely at making hats of a superior description from the leaves of the celebrated cocos-de-mer (*Lodoicea Maldivica*, Pers.), found only at Praslin and Cunense.

The leaves open like a fan; they are of large size, often attaining a length of twenty feet, with a breadth of ten or twelve, and in some few cases thirty feet in length, including the petiole, which is of sufficient strength to support the weight of a man. The foliage is employed to thatch the roofs of houses and sheds, and even for walls. With a hundred leaves a commodious dwelling may be constructed, including even the partitions of the apartments, the doors, and the windows. In the isle of Praslin most of the cabins and warehouses are thus made. The down attached to the young leaves serves for filling mattresses and pillows; the ribs and fibres of the petiole constitute baskets and brooms. The young foliage affords the material for the hats. For this purpose the unexpanded leaves only are taken, dried in the sun, and cut into longitudinal slips, two or three lines in breadth, which are then plaited, and scarcely any other covering for the head is worn by the natives of the Seychelles.

The leaves of many wild plants yield excellent fibre, such as the agave, the pine-apple, the New Zealand flax, and others. The fine white fibres of the pine-apple leaves have been formed into the most delicate fabrics, as well as fishing-lines, ropes, &c. Unlike other fibres, they are not injured by immersion in water—a property much increased by tanning, which process is constantly used by the natives of India. In Malacca and Singapore a trade is carried on

with China in these fibres, which are there used in the manufacture of linen stuff. As a substitute for flax, they are, perhaps, the most valuable of Indian fibres.

The utilisation of the fibre from the leaves of the pine-apple is almost entirely neglected in the countries of its abundant growth. I have in my collection fibre from the leaves of the black Antigua pine, and from the Pinguin pine of Jamaica, which is occasionally made into common ropes in the West Indies, but is not the object of any regular manufacture, the expense of labour in those colonies rendering it more advantageous to import from England cordage ready made. At Singapore the Chinese settlers obtain fibre from the leaves of the wild pine-apple, which, being imported to China, is employed there in making linen. Lieut.-Colonel Watson, writing from the sanatory station of Cheera Runji, states that the pine-apple plant flourishes in great abundance in the adjacent valleys, 4200 feet above the level of the sea, and that the leaves are gathered by the natives for the purpose of obtaining from them, by a very simple process, a strong fibre, employed as the material of the net-pouches or bags in common use among them. In such localities as the Bahamas islets and the Azores, where the pine-apple is grown on a large scale solely for its fruit for shipment, surely the leaves could be utilised for fibre, by a cheap machine, thus adding to the cultivator's profits?

Plantain leaves (*Musa*) are converted in Africa into spoons, plates, and even bottles. They are also made into thatch, fuel, and a substitute for wrapping-paper. From their cooling nature, the leaves are generally used in the tropics to dress blisters. The leaves of *Abelmoschus esculentus* are used for poultices. In Africa, the leaves of *Adansonia digitata* are also made into poultices and fomentations for rheumatic affections of the limbs and irritable inflammatory ulcers. The natives eat the leaves with their food, and they are considered cooling and useful in restraining excessive perspiration; they are also used for leaven. The leaves of several species of *Amaranthus* are employed as emollient poultices in India.

A clean leaf of the *Dillenia speciosa* forms the plate of the Dyak. The leaves, which are hard and rough, are used for polishing furniture, like others of the same family.

The leaves of a plant called "bua palas," probably a *Dillenia*, are used in Sumatra for polishing creeses. The rough leaves of the *Curatella alata* and *C. Americana* are used in Guiana and Trinidad for polishing bows, sabres, &c. The leaves of *Sponea aspera* and *Andaresa* are used in India for polishing horns, &c. Cadjan fans painted, coloured Palmyra fans, and various palm fans, are common in India.

The leaves of the *Bergera Koenigii* are mixed by the natives of India in their curries, to which they impart an agreeable flavour. When rubbed together, they emit a pleasant aromatic smell. They retain this flavour when dried, and are sold in that state in the bazaars. The mucilaginous leaves of *Cassia Tora* have many medicinal uses in India.

Baskets for catching fish, shrimps, &c., are made of the ligneous ribs of the leaflet of the cocoa palm. The same substance is employed by the natives for many of the purposes for which we use pins. A bundle of these ribs is in universal use, as a broom to sweep the cottages; and when an European asks for a tooth-pick, his servant brings him a portion of one of these fibres. The South Sea Islanders make the teeth of their hair combs of this part of the leaf. In a domestic state, elephants are fed chiefly upon cocoa-nut leaves, and this animal evinces much sagacity in separating the elastic woody fibre from the thinner margin of the leaf. For temporary purposes, cadjan houses are frequently constructed both by natives and Europeans. Except the framework, every part of the house, walls, and roof, is formed of cocoa-nut leaves, and they are capable of resisting all kinds of weather for a year or more.

Boats are rowed with the centre rib of the cocoa-nut leaf, in which operation it forms a substitute for paddles. The end of this part of the leaf, when well bruised, and thereby converted into a brush, is used for a variety of purposes, such as whitewashing houses, &c.

In British Guiana, the natives make a species of Æolian harp of the stipe of the leaf of a cocoa-nut tree; and some tribes split the stipes, and after rendering the split portions very thin, they are attached together laterally by means of a silky grass, thereby forming a sail for canoes.

A tent or hut made of Talipot leaves sent home from Ceylon for the London International Exhibition of 1862

was set up in the gardens of the Royal Horticultural Society, but it could not stand our inclement climate, for the sharp gales soon shattered the dry leaves to pieces.

Some neat kinds of basket-work have been made from the leaves of the screw pine; it has also being tried for paper, and yields it of good quality, light and strong. Further experiments are required to separate the green part of the pulp from the white short fibre.

Leaves are more or less popular for garnishing, but it has often surprised me (says a correspondent of the *Garden*) that they are so little used for flavouring. With the exception of sweet and bitter herbs grown chiefly for the purpose, and parsley (which is neither bitter nor sweet, but the most popular of all flavouring plants), comparatively few other leaves are used. Perhaps I ought also to except the sweet bay, which is popular in rice and other puddings, and certainly imparts one of the most pleasant and exquisite flavours. But, on the other hand, what a waste there is of the flavouring properties of peach, almond, and laurel leaves, so richly charged with the essence of bitter almonds, so much used in most kitchens? Of course, such leaves must be used with caution, but so must the spirit as well. An infusion of these could readily be made, either green or dry, and a tea- or table-spoonful of the flavouring liquid used. One of the most useful and harmless of all leaves for flavouring is that of the common syringa. When cucumbers are scarce, these are a perfect substitute in salads or anything in which that flavour is desired. The taste is not only like that of cucumbers, but identical—a curious instance of the correlation of flavours in widely different families. Again, the young leaves of cucumbers have a striking likeness in the way of flavour to that of the fruit. The same may be affirmed of carrot-tops, which are as like carrots in taste as may be. In most gardens there is a prodigious waste of celery flavour in the sacrifice of the external leaves and their partially blanched footstalks. Scores of sticks of celery are cut up into soup, when the outsides would flavour it equally well or better. The young leaves of gooseberries added to bottled fruit give a fresher flavour and a greener colour to pies and tarts. The leaves of the flowering currant give a sort of intermediate flavour between that of black currants

and red. Orange, citron, and lemon leaves impart a flavouring equal to that of the fruit and rind combined, and somewhat different from both. A few leaves added to pies, or boiled in the milk used to bake with rice, or formed into crusts or paste, impart an admirable and almost inimitable bouquet. In short, leaves are not half so much used for seasoning purposes as they might be.

A curious application is the utilisation of the acicular leaflets of pine trees. Near Breslau, in Silesia, are two establishments, one a factory where the pine leaves are converted into what is called "forest wool" or wadding; the other an establishment for invalids, where the waters used in the manufacture of this pine wool are employed as curative agents. The manufacture has extended, for there are now factories at Runda, in the Thüringer Wald, at Jonkoping, in Sweden, Wageningen, in Holland, in parts of France, and other places. Several cases of these products were shown at the last Paris and Havre Exhibitions, which contained various illustrations in the shape of wool for stuffing mattresses and other articles of furniture instead of horsehair, wadded blankets, and vegetable wadding, and hygienic flannel for medical application: essential oil for rheumatism and skin diseases, cloth made from the fibre, articles of dress, such as inner vests, drawers, hose, shirts, coverlets, chest preservers, &c., and other useful applications. In the preparation of the textile material an ethereal oil is produced, which is employed as a curative agent for burning, and as a useful solvent. The liquid remaining from the decoction of the leaves is used for medical baths. The membranous substance and refuse are compressed into blocks and used as fuel; from the resinous matter they contain, sufficient gas is produced for illuminating the factory in which the manufacture is carried on.

It is asserted that articles made of this vegetable wool are not attacked by vermin: it maintains an even degree of heat, is a sure preventive against humidity, and is especially recommended for rheumatic patients.

Professor Betschler, of the Clinical Institution, and Professor Ebers, of Breslau, both strongly recommend these products; and they are extensively used in the Royal Hospital at Berlin. Whether they deserve or not all the high encomiums that have been passed upon them, it is

nevertheless an important fact that a material, before considered useless, is now converted into articles of domestic utility and commercial importance.

Mr. C. G. Fabian, of Breslau, Prussia, showed a collection at the New York Exhibition in 1853. The product is obtained by treating the pine-leaves with a strong boiling solution of carbonate of soda.

A Swedish exhibitor of those products, Mr. J. M. Majeran, of Jonkoping, at the International Exhibition in 1862, stated the prices at which he could supply them as follows :—

	£	s.	*d.*	
Fine pressed wool	2	10	0	per cwt.
Rough do.	2	0	0	"
Ethereal oil	0	8	0	per lb.
Decoction	0	0	8	"
Balsamic extract	0	0	6	"

free in Gothenburg, now at Wageningen, in Holland.

The points of the branches of *Pinus sylvestris* are considered an antiscorbutic remedy in Russia. The leaves of *Rhododendron davuricum* are also made there into a diaphoretic tea. The leaves of *Osyris nepalensis* also form a sort of tea, and the list of various tea substitutes of different countries is much too extensive to enumerate here.

Mr. C. Muratore, of Algeria, has sought to utilise the *Pistacia lentiscus*, which is found in abundance growing spontaneously in Africa. To this end he takes the leaves and fruits of the tree and boils them in water, filters the liquor and precipitates it by a solution of salts of iron. The decoction dyes objects black, which are plunged into a solution of iron, He has also obtained a deep blue liquor, which communicates, in its boiling state, to yarn, and to tissues, a handsome black colour, comparable to that obtained from logwood, gall-nuts, &c. To facilitate transport the colouring matter is reduced to powder, which powder mixed with oil can be used for painting. Other colours may be obtained by combining different salts or acids. The stalks and branches of the tree also furnish this colouring matter, but not in such quantity as the leaves and fruit.

When gathered in autumn, before they are injured by the frost, the leaves of the beech, on account of their

elastic quality, make better palliases than either straw or chaff, and they last seven or eight years. The dried leaves of the wrack-grass (*Zostera marina*) are used for the same purpose in Holland, and also as a packing material. The substance has been frequently recommended for paper-pulp, and some years ago it was largely puffed up under the impression that its fibre might prove a cotton substitute.

The leaves of the chicory plant, which is extensively grown in Germany, Belgium, and Italy, are esteemed an excellent fodder for horses, cattle, and sheep, either green or dry. But (as in the case of the tops of turnips, which are dragged up and carted from the land) when chicory is grown for the sake of its roots, more of the tops get ploughed in for manure than are removed. Some growers have lately been using the leaves as a substitute for woad, or rather as an adulterator of it; but how far they will answer the purpose it is premature to say. The leaves are also said to be used for adulterating tobacco.

But there are many other uses for leaves. Experiments have been made in India with the dried leaves of trees, the result of which was, that if they are compressed, they make excellent fuel for locomotives. The quantity of leaves which fall every year from trees is of no small weight. Old forests contain a considerable depth of dead leaves, the accumulation of many years.

There is one harvest which is abundant annually, and of which nine-tenths of our farmers have yet to gather their first crop—the leaves from our various deciduous trees, which fall with the heavy frosts, and carpet the ground and fill the hollows, there to decay and furnish food for their successors.

The leaves of plants are much richer in fertilising material than the wood. In the case of the elm, chemical analysis shows this, as the leaves contain 11 per cent. of ashes, while the wood gives only 2 per cent., and in other varieties the difference is greater. Every one has noticed after plants have got a foothold, and are fairly rooted on very poor land, that the annual deposit of leaves upon the surface soon furnishes sufficient fertilising matter to cause a thrifty, rank growth. Now this valuable crop is too apt to be neglected; it will pay to secure it. As a general thing

gardeners understand their value, and where they can easily obtain them, they do so and add to their compost. Most farmers are so situated that they can readily obtain large quantities by expending a little labour. Besides their value for the compost heap, they make the best of bedding for the pig-stye or stable, being light, dry, and warm.

Leaves and loam form an excellent material for covering vegetables buried in the fields or garden. Nature has designed the fallen leaves as a shield to the tree roots against the frost; a thin coating being almost impervious to that element, they are, herefore, exactly fitted for the use above mentioned. No better manure can be used upon the garden, as it will make the soil light and airy, and at the same time give it the primitive qualities of fertility.

A Vermonter has recently tanned several sides of leather with lye leached from forest leaves. He has been experimenting with leaves for nearly two months with satisfactory results. One ton of leaves, it is asserted, will tan as much leather as five cords of bark, and will complete the process in half the time. When leaves and bark are mixed in equal proportions, one-fourth of the time is saved. The leather tanned by this process, it is claimed, is more flexible and smoother than that tanned with bark, while the strength of the raw hide is retained in a greater degree.

In Italy an extraordinary quantity of wild plants supply materials for manufacturing and industrial purposes; the willow, for the chairs of Chiavari; the much-prized chip hats of the province of Modena; the dwarf-palm (*Chamærops humilis*), with the leaves of which hats, baskets, brooms, and rope are madé in Sicily, and, lastly, wheat straw, which is used for several purposes—especially for making straw hats—the manufacture of which gives employment to many families in the neighbourhood of Florence. At Syracuse paper is made with the papyrus, in imitation of that of the Egyptians; straw cases, and the rush are used to enclose wine bottles and oil flasks, and the willow and osier are used as a protection to larger glass-bottles. Reeds serve for many agricultural purposes, and for building. With the Sorghum brooms are made; tinder is made of several sorts of fungi; the stalks of hemp are used for matches, and the pine cones as fuel; plait is made

of the glumes or husks of Indian corn, and clothes- and horse-brushes of the roots of *Chrysopogon Gryllus.*

Medals have been given from time to time by the Society of Arts for hats and bonnets made of the straw of various indigenous grasses, such as *Poa pratensis*, *Molinia cærulia*, *Agrostis canina* (brown bent grass), *Agrostis stolonifera* (a sort of couch-grass), *Lolium perenne* (rye-grass), *Avena flavescens* (yellow oat-grass), *Cynosurus cristatus* (crested dogs'-tail grass), *Anthoxanthum odoratum* (sweet-scented vernal grass), *Alopecurus pratensis* (meadow fox-tail grass), *Phleum pratense* (cats'-tail grass).

Straw has frequently been considered the emblem of worthlesness, but still ingenuity and taste may vastly enhance its economic value, and convert it from a waste product to an important article of commerce.

Its economic uses are manifold; but there are many applications of the culms of grasses, and the leaves of trees, and plants, &c., of which little is generally known, and their importance quite unappreciated in consequence.

The uses of straw for litter and for feeding stock, for thatch and for brickmaking, as a packing material and for stuffing palliases, are of course generally known. Straw has also been again brought extensively into use of late years as a paper material.

Buckwheat straw has been used for dyeing yellow. We do not use straw shoes for our horses, nor for our own pedal supports, as they do in Japan; but we do use straw for making hats and bonnets, and that to a much larger extent than many are at all aware of. Few, probably, would suppose that the straw-plait manufacture carried on in one or two towns in the home counties, gives employment to 80,000 or 90,000 persons, chiefly females, and the produce is valued annually at a million and a-half sterling. Yet these were facts stated in a most interesting paper on the straw-plait trade, read before the Society of Arts, London, in 1860.

Plaiting of straws, grasses, and chips into hats and different articles of wear, is far from being confined to Europe or to civilised countries. The art is indeed found to obtain, in different degrees of extent and excellence, in nearly every part of the world. In the southern provinces of China, where in summer the population use no other

head covering, and where the mandarins wear those umbrella hats with tremendously wide brims, the quantity of straw plaited is prodigious. In Japan, in proportion to the population, the consumption is almost equally great. "When on a journey," says Thunberg, "all the Japanese wear a conical hat, made of a species of grass, plaited and tied with a string." He also observes that all the fishermen wear hats of the same material and shape. But, in addition to this extensive use, the Japanese hardly ever wear any shoes or slippers but such as are made of plaited straw. "This," remarks the same traveller, "is the most shabby and indifferent part of their dress, and yet in equal use with the high and the low, the rich and the poor. They are made of rice straw plaited, and by no means strong. They cost, however, a mere trifle; they are found exposed for sale in every town and in every village, and the pedestrian supplies himself with new shoes as he goes along, while the more provident man always carries two or three pairs with him for use, throwing them away as they wear out. Old worn-out shoes of this description are found lying everywhere by the sides of the roads, especially near rivulets, where travellers, on changing their shoes, have an opportunity at the same time of washing their feet. In very wet weather, they use wooden clogs, which are attached to their straw-plaited shoes by ties also made of straw-plait. People of very high rank sometimes wear slippers made of fine slips of rattan neatly plaited.

Uses of Rattans.—Mats made from split canes or rattans are exported from China to all parts of the world. The table mats are very beautiful. Thousands of people are employed there in the manufacture of mats of bamboo for boats' sails. The annual export of matting from China to the United States alone is upwards of 10,000 rolls of 40 yards each.

One of the most useful of the many wild products of the Eastern forests are the canes known as rattans, which are now so largely imported and used for a variety of economic purposes. Until collected and utilised, they are essentially a waste substance. It was only in the early part of this century that the first importation took place, and it is but very recently that they have formed any considerable item in the commerce of the country. As comparatively little

is known respecting the origin, sources of supply, and general application of these canes, some few observations thereon may not be without general interest.

They are the trailing stems of different species of *Calamus*. These plants, though generally arranged among the palm tribe, hold a middle station between the palms and grasses, having the habit of the former, while their inflorescence is that of the latter. The several species yielding the rattans of commerce have not been distinctly identified. The following are some of the species best known in India and the neighbouring countries.

C. rudentum, Lour., native of the Moluccas; *C. erectus*, indigenous to Silhet; *C. verus*, Lour., Moluccas and Cochin-China; *C. scipionum*, Lour., which yields the Malacca cane; *C. Royleanus*, a species found in Dheyra Doon; *C. Draco*, Willd., Sumatra and the Moluccas; *C. gracilis* and *tenuis*, both of Chittagong, with several others. In 1870 we received more than 24½ million rattans from Singapore, and 8¼ millions from other localities, besides about 6 million of other canes and sticks; the aggregate value of these imports being 83,841*l*. In 1853 we only received 10¾ million rattans. The principal importers are Messrs. Meyers and Davis, of Southwark Street, London, whose warehouse stock is immense.

Some rattans grow to an immense length, climbing over the highest trees in the forest, even as long as 500 or 600 feet. Such have been the dimensions given to the *C. extensus*, a native of Silhet, and *C. rudentum*, of Cochin-China. At the Paris Exhibition of 1855 Ceylon section, and of 1867, in the Spanish collection from the Philippines rattans were shown of half that length.

Several millions are annually exported from India, being brought down from the valleys of the Himalaya to the plains, and large shipments are made from Singapore, being brought there from Borneo, Java, and other places. The annual estimated consumption of rattans in Europe, the East, and America, is upwards of 25,000 tons.

The native who collects rattans proceeds into the forest with his parang or bill-hook, and cuts as many as he is able to carry away. His mode of procedure is this:—He makes a notch in the tree at the foot of which the rattan is growing, and, cutting the latter, strips off a small portion of the

outer bark, and inserts the part that is peeled into the notch. The rattan now being pulled through as long as it continues of an equal size, is by this operation neatly and readily freed from its epidermis. When the woodcutter has obtained by this means from 300 to 400 rattans—being as many as an individual can conveniently carry in their moist and undried state—he sits down and ties them up in bundles of from 25 to 100, each cane being first doubled. After drying, they are fit for the market without further preparation. From the small labour expended in bringing them to market, they can be sold at a very cheap rate. The natives always vend them by tale, but the European residents and the Chinese sell them by weight, in piculs. In India and this country they are sold by tale. The species of *Calamus*, furnishing the rattans of commerce, abound in the islands of the Indian Archipelago, as well as in the Malayan Peninsula. The principal places of production are—Banjarmassing (fine quality), Pontianak (common), Cotie (small and fine), Sarawak (both fine and coarse), and Sambàs (very long and very mixed), all in Borneo; Jambi, in Sumatra; Pandagon (glossy kind), on the west coast of Sumatra and Perak (Malayan Peninsula). The Bugis traders of Borneo barter them from the natives for various European and Chinese manufactures. The canes are then taken by these traders to Batavia, Sourabaya, Singapore, Penang, and other ports, where they are purchased by European merchants, and by them shipped principally to London and Liverpool. The majority of those produced at Banjarmasing and Cotie are bought by the Dutch East India Company, and find their way to Holland. Those produced at Perak, which are very good and bright, are sent to Penang, and re-shipped to London, hence known as Penang quality.

The whole of the rivers of the north of Borneo, for miles up, abound in rattans. A writer who had visited the coasts stated not long ago that four thousand tons might be easily cut down every year without exhausting it, and sent by junks to China and Singapore. Two or three vessels of the largest size could annually load with them in Maludu Bay. The inhabitants would contract to cut them down for a trifle, but the great expense of transport and bringing to shipping ports, with freight, constitutes a charge of 50 to

75 per cent. on the first cost. A few species are found in the Madras territories, but in India they chiefly abound in the forests of the districts of Chittagong, Silhet, and Assam, whence they extend along the foot of the Himalayas as far north as the Deyra Doon. These canes are abundant in all the moist tropical parts of the East, both on the Continent and in islands.

In the Eastern Archipelago, the native, too indolent to cultivate the soil, searches the forest for rattans, canes, barks, and materials for mats, roofs, baskets, and receptacles of various kinds. The East Indian rattans from Calcutta are very inferior and usually glossy, while those from the Eastern Archipelago are, except those from Penang and Sumatra, not glossy.

The common rattan is yielded by the *Calamus Draco*, of Willd., the *C. Rotan*, of Linn., and *C. Roxburghii*, of Griffith; it is a stouter kind than the others. The stems of *C. fasciculatus*, Roxb., are, when divested of their sheaths, about as thick as the forefinger, and are used as walking-sticks.

Rattans are extensively used as props for plants, cables, ropes, wicker work, baskets, chairs, couches, as a great substitute for whalebone, &c. Being very strong, and at the same time flexible, they are admirably adapted for those purposes. Cordage and cables for vessels are sometimes made in the East from the stems twisted together. Their strength is exceedingly great when several are twisted in this way, and they answer all the purposes of the strongest cables. In China and Japan they are in great request. Marco Polo refers to their uses in those countries. Talking of a certain place in China, he says, "They do not employ hempen cordage, excepting for the masts and sails, standing and running rigging. They have canes of the length of fifteen paces, such as have been already described, which they split in their whole length into very thin pieces, and these, by twisting them together, they form into ropes three hundred paces long; so skilfully are they manufactured, that they are equal in strength to cordage made of hemp. With these ropes the vessels are tracked along the rivers, by means of ten or twelve horses to each, as well upwards against the current as in the opposite direction." Here he evidently refers to the rattan canes, and not to bamboos as supposed by some.

For cane-work, rattans should be long, of a bright pale yellow colour, and of a small size, not brittle or subject to break. They are usually purchased by the 100, but in China are sold by the picul (133⅓ lbs.) which contains from nine to twelve bundles and upwards, according to size. Such as are black or dark coloured, that snap short on being bent, should be rejected. The Dutch Trading Society import about 400,000 bundles annually from Java and the East Indian Islands, and about as many more are imported and sold in Holland by private merchants.

In Japan all sorts of basket work is made of split cane, and even cabinets with drawers. Cane is also plaited or twisted into cordage, and slender fibres are made to answer the ordinary purposes of twine. In China, in Java and Sumatra, and indeed throughout the Eastern Islands, vessels are furnished with cables formed of canes twisted or plaited. The species employed for this purpose is probably the *Calamus rudentum*, of Loureiro, which that author describes as being twisted into ropes in these Eastern regions, and employed, among other things, for dragging great weights, and for binding untamed elephants. So Dampier says, " Here we made two new cables of rattans, each of them four inches about. Our captain bought the rattans, and hired a Chinese to work them, who was very expert in making such wooden cables. These cables I found serviceable enough after, in mooring the vessel with either of them; for when I carried out the anchor, the cable being thrown out after me, swam like cork in the sea, so that I could see when it was tight—which we cannot so well discern in our hempen cables, whose weight sinks them down; nor can we carry them out except by placing two or three boats at some distance asunder, to buoy up the cable, while the long-boat rows out the anchor." The tow-ropes mentioned by Marco Polo, as used by the Chinese for tracking vessels on their numerous rivers and canals, seem also to have been made of cane—and not of bamboo, as sometimes stated—they were split in their whole length of about thirty feet, and then twisted together into strong ropes, some hundred feet in length.

Mr. G. Bennett says, in his 'Wanderings,' ii. p. 121, "that he remarked some Chinese one morning, near Macao, engaged in making very durable ropes from rattans. The

rattans were split longitudinally, soaked, and attached to a wheel, which one person was keeping in motion, whilst another was binding the split rattans together, adding others to the length from a quantity he carried around his waist, until the required length of the rope was completed."

Rattans are also occasionally used in India for making bridges, as described in the following passage extracted from Dr. Hooker's 'Himalayan Journals':—"Soon after crossing the Rungmo, where it falls into the Rungeet, at a most wild and beautiful spot, I saw," says the enterprising traveller, "for the first time, one of the most characteristic of Himalayan works of art—*a cane bridge*. . . . A fig-tree, projecting over the stream, growing out of a mass of rocks, its roots interlaced and grasping at every available support, formed one pier for the canes; that on the opposite bank was constructed of strong piles, propped with large stones; and between them swung the bridge, about eighty yards long, ever rocking over the torrent (forty feet below). The lightness and extreme simplicity of its structure were very remarkable. Two parallel canes, on the same horizontal plane, were stretched across the stream; from them others hung in loops, and along the loops were laid one or two bamboo stems for flooring; cross pieces below this flooring hung from the two upper canes, which they thus served to keep apart. The traveller grasps one of the canes in either hand, and walks along the loose bamboos laid on the swinging loops; the motion is great, and the rattling of the loose dry bamboos is neither a musical sound, nor one calculated to inspire confidence, the whole structure seeming as if about to break down. With shoes it is not easy to walk, and even with bare feet it is often difficult, there being frequently but one bamboo, which, if the fastening is loose, tilts up, leaving the pedestrian suspended over the torrent by the slender canes. When properly and strongly made, with good fastenings, and a floor of bamboos laid transversely, these bridges are easy to cross. The canes are procured from a species of *Calamus*; they are as thick as the finger, and twenty or thirty yards long, knotted together, and the other pieces are fastened to them by strips of the same plant. A Lepcha, carrying 140 lbs. on his back, crosses without hesitation, slowly but steadily, and with perfect confidence."

Rattans form a very important article of trade in Singapore, Penang, and Batavia, where large quantities are sold for China, America, and Europe. The Chinese apply them to a great number of purposes, especially for cordage, door mats, chairs, baskets, and beds; and they build houses or sheds in the south of China of them, for about five dollars each house.

Messrs. G. W. Reynolds & Co., of Birmingham, make wicker-work baskets of them for protecting sulphuric acid bottles; several of the leading acid makers were applied to for orders, the result was most satisfactory, and led to a large business. Messrs. Reynolds, assisted by Mr. Dance, thereupon put up machinery for making the baskets, and their manufacture is likely to prove one of the greatest boons to the sulphuric and other acid manufacturers, as the old willow baskets were a continual source of annoyance; for when the acid is spilled upon the willow work, it soon becomes rotten, and hence the carboys are frequently broken. The rattans having a large amount of silica on the outer bark, the acid has no effect upon them, and the baskets appear as good after three months' wear as when first made. This species of covering is especially suited for protecting carboys of acid intended for exportation.

Rattan skips have now quite superseded, in cotton mills, sugar refineries, railway companies, and most large factories, those made of willow, buffalo hide, &c., having the advantage of durability, smoothness, and elasticity, and will repair year after year, whilst willow will not. The saving to some of the large cotton spinners is immense; some estimate of the gain may be formed from the fact, that the cost of a stock of skips, or baskets, to one cotton manufacturer, is 2600*l.* These skips are also made in very large quantities by Messrs. Reynolds and Dance's patent machinery.

The numerous economic uses to which rattans might be applied in this country are not yet fully developed. They are however employed with advantage as baskets for fruiterers, gardeners, hucksters, hosiers, potters, and grocers; for coal baskets and clothes baskets; for the cars of balloons; for rustic and garden chairs; for lattice work; for meat safes; for rough door matting and brooms, and very many other purposes. Notwithstanding the great distance they are brought, they are sold as cheap in the

London and Liverpool markets as in China. As showing the benefits of extended commerce, I may state that a working whipmaker remembers rattans costing 3*s.* instead of as now 3*d.* per lb., and when whalebone, which was used for the same purpose, was sold at 1*s.* per lb. and is now worth 7*s.* 6*d.* to 8*s.* From Java 80,000 to 90,000 piculs (equal to about 12 bundles each) of rattans are exported annually.

On the Continent the use of rattans has attained very large dimensions. The firm of Van Oye van Duerne, of Antwerp, which gives employment to 200 people, imports 3500 tons of rattans annually, and by improved machinery for working them up, has largely extended their industrial applications. For seats to chairs, rattans have almost entirely superseded straw and rushes on the Continent, and osiers in basket-work. This firm usually makes a fine display of its products at all the International Exhibitions; of the rattans as received in their natural states, in tied-up bundles of 100, washed, bleached, and cut in different lengths for rustic buildings, trellis-work, and canes; the bark peeled off for caning chairs, couches, carriages, basket-work, and fine hat plaiting; imitation whalebone for the ribs of cheap parasols and umbrellas, crinoline hoops, and ladies' stay-bones; white and black varnished canes; mats made of the shavings; the same twisted or curled, either white or dyed black, for stuffing mattresses.

The cane is divided by machinery into eight, nine, or as many sections as may be required for basket or cane work, or for umbrella ribs. The latter are shaped, cut, ends turned and compressed entirely by machinery. About 50 per cent. of the rattans are used for plaiting work, and the rest for umbrella ribs, which are turned, pointed, dyed, varnished, and polished. A set of ribs for a parasol costs only ½*d.* to 1*d.*, and for an umbrella 2½*d.* instead of 2*s.* 6*d.* or 3*s.* for whalebone. It takes 4 lbs. of rough rattan to yield 1 lb. of finished bark material for caning. The cane ribs for umbrellas are dyed black by logwood and sulphate of iron. The pith can be stained all colours, but the silicious bark, from its glossy exterior, is unable to be dyed. The rounds or centres of the rattans for basket-work range in size from that of a pin-wire to 15 dimensions, or

the full size of the ordinary cane, minus the bark, and these are in great demand.

Even the waste or *débris* in peeling is not lost, but is converted into "crin vegetal," or twisted fibre for filling mattresses and making mats, and also for ties or bands for agricultural purposes. As the mattresses retain no odour, but are always sweet and pleasant, they are much used in hospitals on the Continent, as they can be sold wholesale as low as 4*d.* to 8*d.* each. This material also replaces hay and straw for packing purposes. The mats made of it are sold at from 2*s.* to 2*s.* 6*d.* the square yard.

The Oriental Fibre Mat and Matting Company, Highworth, have also gone into this manufacture in England. and are utilising rattan waste for strong door-mats.

Ground rattans differ from the climbing rattans. They are imported for making walking-sticks, and should be chosen with short joints, tapered, heavy, and well glazed. Those with the roots are most esteemed. Care should be taken to have them of sufficient length to make either one, two, three, or four sticks, each 38 to 42 inches long. Such as are dark-coloured, badly glazed, or decayed, should be rejected.

Potash and Pearl Ash.—In the destructive operations carried on in the process of clearing and cultivating land, whether in paring and burning the soil, or destroying the fern, brushwood, or timber trees which cumber the land, a waste product is obtained which requires notice in this place, from having a high commercial value; since we pay for the foreign supplies of this product from 150,000*l.* to 200,000*l.* a year. It is not only large trees which contain potash in their sap, herbaceous vegetables also contain it in even larger proportions; and when they can be burned, the residue furnishes a source of potash.

The manufacturers of beetroot-sugar who adopt Dubrunfant's process, for utilising the residue from the distillation of alcohol liquors from fermenting molasses, buy the raw material resulting from the incineration of the wine lees of other manufacturers, and add them to their own, and separate completely the carbonates of potash and soda which they contain.

Potash derives its common name from being first obtained from the ashes of vegetable substances which had

been burned in iron pots. It is found in almost all land plants in combination with the tartaric, citric, or other vegetable acid. It exists, however, in plants in varying proportions. The leaves of trees when burnt generally produce more potash than the branches, and the stem of the tree the least of all; herbs produce four or five times, and shrubs three or four times, as much as trees. Maize is one of those plants in which potash preponderates, for analysis of its ashes gives 71 per cent. of potash and soda; the ripe seeds contain over 23 per cent.

The following figures show the amount of potash contained in 1000 lbs. of ashes, made from burning different kinds of wood :—Pine, $\frac{1}{2}$ lb.; poplar, $\frac{3}{4}$ lb.; beech, $1\frac{1}{2}$ lb.; maple, 4 lbs.; oak, $2\frac{1}{4}$ lbs.; beech bark, 6 lbs.; wheat straw, 4lbs.; oak leaves, 24 lbs.; stems of potatoes, 55 lbs.; wormwood, 73 lbs.; sunflower stalks, 19 lbs. The remaining portion of the ash, consisting of carbonate and phosphate of lime, iron, manganese, alumina, and silica, is an excellent fertiliser. The cobs of Indian corn might be made available as a source of supply of potash, for they contain on an average in 1000 parts 7·62 of carbonate of potash, or about twice as much as the best kinds of wood.

Taking the average production of maize in the United States, there might be obtained 51,612 tons of carbonate of potash yearly, and a considerable quantity of chloride of potassium could also be produced.

The ashes of land-plants yield principally the salts of potash, such as barilla, while those of marine-plants afford a large quantity of soda-salts.

Potash is of great importance in the arts, being largely employed in making alum, soap, flint-glass, prussiate of potash, in bleaching, the rectification of spirits, and for other purposes. In North America, Russia, Tasmania, and other places, where timber is an incumbrance upon the soil, it is felled, piled up in pyramids, and burned, solely with the view to the manufacture of potash. The ashes, when the heaps are consumed, must be sifted; and the larger parts, or charcoal, returned to the fire, and burned to ashes. These ashes, as soon as the sifting is completed, are stowed away under cover, until it is desirable to commence the lixiviation.

The ashes received from the United States and our

North American colonies contain a greater proportion of red potash than those from Russia ; and hence the difference in price is as much as 4*s*. or 5*s*. per cwt. between them.

The simplest and rudest preparation of potash is called ash-balls in England, and wood-ash in Ireland, and is obtained by burning the common fern or brake, thistles, dock, or weeds of any kind. The reddish-grey ash, being carefully collected, is sprinkled with a little water, and then moulded by hand into balls from three to four inches in diameter, which, when they have acquired a certain hardness and solidity by drying in the sun, are ready for sale. It is an object of importance to determine the value of the carbonates of potash and soda met with in commerce, by ascertaining the amount of available alkali they contain. The available alkali is that which exists in the free or caustic state, and that which exists as carbonate.

The alkalimetrical processes usually employed are sufficient for ascertaining the strength of the alkalies of commerce ; but do not furnish any indication of the nature of these alkalies, as they do not distinguish pure potashes from those which have been mixed with soda. The Society of Pharmacy of Paris some years ago offered a premium of £125 for the best treatise describing an easy and commercial process for recognising the presence and proportion of soda in the potash of commerce.

The best pink Canadian potashes contain pretty uniformly 60 per cent. of absolute potassa, and the best potashes 50 per cent. ; the alkali in the former being nearly in a caustic state, and in the latter carbonated. All kinds of vegetables do not yield the same proportion of potash. The more succulent the plant the more it affords, for it is only in the juices that the vegetable salts reside, which are converted by incineration into alkaline matter. Herbaceous weeds yield more potash than shrubs, and shrubs than trees ; and for a like reason twigs and leaves are more productive than timber. But plants in all cases are richest in alkaline salts when they have arrived at maturity. The soil in which they grow also influences the quantity of saline matter.

On many kinds of soils in North America the burning of timber has a beneficial effect, which may be ascribed to the agency of heat and the potash supplied from the ashes.

All plants contain alkali, either potash or soda; hence salts of these alkalies are constituents of many of the best manures; and the ashes of plants, rich in alkali, have always a beneficial effect when applied to land. The earthy phosphates and alkaline salts are the most important of the salient constituents of manure.

The trade in potash and pearlash has a particular, as well as a general, beneficial effect upon the interests of the settler in the woods; and the very obstruction to cultivation is frequently converted to purposes of immediate and direct gain. This branch of Canadian industry might be more extensively engaged in, with profit, as there is a steady demand for this article, at remunerative prices. Potash is largely manufactured in Lower Canada, some of the wealthiest *habitans* (or French settlers) being largely engaged in it. It requires but a small capital, and the time occupied in the process is very short. There are millions of bushels of wood-ashes wasted in Upper Canada which might and ought to be turned to good account. At present large quantities of ashes are collected in Canada by the Americans, and carried to Ogdensburgh and elsewhere, to be there manufactured into a valuable article of export. The export of pot and pearl ashes from Canada used to be very considerable. Twenty or thirty years ago 179,000 cwts. were shipped. Now, however, the shipments rarely reach 100,000 cwts.

In 1868 and 1869 the average export from Canada was 16,500 barrels of potash and 5,500 barrels of pearl ash. The barrels weigh about five cwt. In 1863 and 1864 we imported into this country 200,000 cwts. of pot and pearl ash and alkali, and in 1871 we only received half that quantity.

Many emigrants arriving in Canada with scarcely sufficient means to purchase an ordinary farm, might engage in the manufacture of ashes to great advantage. The ordinary risks of agriculture in such a climate are avoided. The yield is certain, while the price is remunerative.

There are inspectors appointed at Montreal, Boston, and New York, to certify the quality of the ashes, pot and pearl, which are each classified into three grades.

The heavy timber chiefly burned in clearing wood land in Canada, is elm, maple, basswood, larch, birch, and brown

ash. The same use can be made of all others that can be got; but those named produce the best and the largest quantity of ashes. In order to keep it uninjured from wet or damp, when the timber is burned the ashes may be collected in a bin or safe, made of small logs, floored with logs or boards, and covered over-head from the rain. The ashes should not be put in or near a house, lest if put in hot they might burn the building. They have been known also to take fire if vegetable oil be poured on cold ashes. In such a safe or bin they may be preserved until sold or otherwise disposed of; and if a fair price can be obtained for them in this state it is better for the new settler to sell them than to boil them himself, if he is not accustomed to the process. The older settlers manufacture their ashes for sale to the country merchants, into what is called the "salts of lye," when there are no purchasers convenient to buy them before taken through any such process. To effect this, they provide themselves with two or more deep tubs, called "leeches," which hold six or eight bushels of ashes, with a spigot in the bottom. These are placed on a stand a foot or two from the ground, with troughs underneath them, to receive the lye when it runs off. A few bricks, stones, or a handful of brushwood are put inside over the spigot, on which is placed a little straw, to prevent the ashes running through or rendering the lye muddy. Over this the dry ashes are placed, nearly filling the leech, and gently pressed down, on which is poured boiling water for the "first run," that is until with it the ashes be perfectly soaked through; cold water may then be used until the strength is taken from the ashes, which is known when the lye running off is waste like water. Two or more kettles or pots are hung over a fire to boil down the liquid that has run from the ashes, one boiler being kept filled from the lye running off the ashes, until all gets boiled down to the consistence of tar, which when cold is as hard or harder than pitch. This substance is the pot or pearl ashes in a crude state. It is readily purchased by all Canadian country merchants, who have works in which it is heated in a furnace until it becomes nearly white, whence its name of pearl ash. The ashes saved from an acre of good hard-wood land will produce three or four, and in some cases five per cent. of salts. A handy man

will boil 1 cwt. a day, and about 16 bushels of ashes will produce so much.

This resource is a great advantage to the new settler, as it affords him some cash for clearing off his land, by producing an article for sale which is always in demand, from what would otherwise be thrown away as being of no use to newly-cleared land.

Sir Wm. Denison, when Governor of Tasmania, in some experiments which he caused to be carried on in that island, found that the proportion of ash obtained from the wood and bark of the trees varied according to the description of timber from 10 to 25 lbs. per ton. The general yield of potash is about 1 lb. to 10 lbs. of ash. Upon a rough computation, the quantity of timber, including leaves and branches, in a heavily-wooded district of that colony, is from 600 to 1200 tons per acre. If, then, the quantity of ash be taken on an average at 10 lbs. per ton of wood, the weight of ash will be from 6000 to 12,000 lbs., and the quantity of potash, from 600 to 1200 lbs.. The value of the potash in the home market is from £36 to £38 per ton.

The virgin forests of Galicia and Bukovina, Austria, furnish annually from the ashes of the decaying pines and beech-trees 9000 to 11,000 metrical quintals. This potash, when refined, sells at from 48¾ to 76 francs per metrical quintal.

In the plateau of eastern Galicia there is also produced annually about 600 metrical quintals of potash obtained from straw, which sells at from 35 to 58 francs the metrical quintal.

In Italy potash is sold at 75 francs the 100 kilogrammes, and in Russia at 9 to 10 francs the 20 kilogrammes.

Whilst potash was in former days foremost in the market among the alkalies, and very cheap, it has risen in later times to an enormous price. It was, therefore, one of the principal problems of technical chemistry either to diminish its use by other bases or by employing the raw materials that are abundant in the mineral kingdom to make its production cheaper and more advanced.

The first successful step was made by using, in many cases, soda, ammonia, or lime, instead of potash. Thus, for instance, pure potash-alum disappeared mostly in commerce, being substituted either by one in which a

certain quantity of potash was replaced by ammonia, or by pure ammonia alum. Whilst in former days in the preparation of chlorate of potash, potash had been exclusively used, of which out of six equivalents five had always been lost as less profitable chloride of potassium, at present five equivalents of lime are taken to one equivalent of potash, whereby all the potash is regained as chlorate, and five equivalents of chloride of calcium instead of five of chloride of potassium. In spite of these and similar substitutes, potash has become more scarce; but still it cannot be given up entirely, for in several important technical operations it is indispensably necessary. Among other cases pure crystal glass cannot be manufactured with soda, which produces a greenish tint upon it, but only with potash. Nor can soda-saltpetre replace potash-saltpetre in the manufacture of gunpowder. In the manufacture of Cyanogen compounds potash will probably always be preferred.

Science, therefore, was obliged to look out for new sources of potash, and to make the utmost use of them. The tedious process by which the vegetable kingdom withdraws the potash from the minerals had to be replaced by quicker operations. The primitive woods of North America (the largest district from which potash was first brought into the market) disappear so rapidly, or their wood can be used in so many other ways, that the old resource of burning the trees into ashes, has lost a great deal of its importance, when compared with the use now made of the new raw materials and the new methods of using them. We obtain potash just as well from the vegetation of the sea and coasts as from the plants of the soil. In addition we have subjected the mineral kingdom to our immediate use by having unlocked the feldspar and other potash silicate, as well as by the treatment of some secondary products of salt mines in Prussia. Even the animal kingdom pays us its tribute of potash.

In the saltstone, under the coloured sandstone, by Stassfurt, in Prussia, there was discovered a double salt consisting of chloride of potassium and chloride of magnesium, that has obtained the name of carnallit, and of which there is such a quantity that its produce of chloride of potassium is estimated at 5,000,000 of tons. In the year 1866, 150,000 tons of this double salt were used up for

chloride of potassium, and the production is still continuing to increase. The feldspar is a very productive source of potash, for it contains 16 per cent. of it. Lawrence effects the liberation by mixing the fine powder with shavings and straw, by setting the mixture up in heaps, and by wetting it from time to time with urine or other liquids containing nitrogen. The fermenting process caused thereby lasts about half a year, when he mixes the whole with slacked lime in a paste, and shapes it into bricks, burns them in a strong red-hot heat, washes them with water that solves the potash, whilst silicate of lime, &c., remains. Hack burns the powdered mineral at the onset with lime, and treats the mass with water under a pressure of eight atmospheres; the solution thus obtained he saturates with carbonic acid, in consequence of which silicic acid and alumina are secreted, but the potash remains solved as a carbonate. Ward employs lime and fluor-spar to decompose the feldspar. None of these methods has hitherto been worked in such a way as to yield profit, but the one or the other, equally with that of Wurtz and Tilghman, by which the alkali is extracted out of feldspar, as chlorate or sulphate, will undoubtedly attain technical importance.

A little more than 500 lbs. of chloride of potassium, besides bromine, iodine, and soda-salts are obtained from 22 tons of wet sea-weed (kelp). This source of potash has now certainly been eclipsed by the discovery of the Stassfurt salt-mines, yet the using up of kelp has not abated, because it is still the most important material from which iodine is derived. About twenty-five years ago Dubrunfaut showed that the molasses which is left in the fabrication of sugar from beet-root can be used up with the greatest advantage for the manufacture of potash, after the sugar, contained in the molasses, has been changed into spirit of wine and distilled; what remains, after the distillation has taken place, needs only to be dried up and burned to ashes. According to Payen the ash of these molasses contains 49·88 per cent. of carbonate of potash. The above method has been generally adopted. The large sugar refinery at Waghaüsel, in Baden, produces about 300 tons per annum of this potash containing 88 to 94 per cent. of carbonate of potash.

In the year 1862 Dr. Hoffman drew attention in his Chemical Report on the London Exhibition to a source of potash which is practised in some parts of France, especially in the great centres of the woollen manufactures at Rheims, Fournier, and Elbœuf. Here the wash liquors in which about 27 million kilos. of wool have been cleaned, are collected on account of the suint (yolk) contained in it. This suint of the wool is a combination of potash with a peculiar acid hitherto little studied, containing nitrogen. According to Chevreul, the raw Merino wool contains not less than one-third of its weight of yolk, ordinary wool less, and this can be easily dissolved in water. Lawrence Smith mentions that 1,167,750 kilogrammes of potash are obtained from the water by drying it up, by burning in a red-hot heat in retorts to gain also gas, tar, and ammonia-water, by extracting with water the remaining coke-like mass, and by allowing it to evaporate, when first sulphate and then muriate of potash crystallize out of it, whereupon the mother-ley, having evaporated, a tolerably pure carbonate of potash remains. Soda compounds are said never to be present.

Soap-boiler's ashes are a mixture of a peculiar description; they are principally the insoluble portion of the barilla, potash or kelp, employed in soap-making, mixed with cinders, lime, salt, and other occasional additions, and also with muriate of potash, common salt, and other saline matters.

Waste India Rubber.—A fortune awaits the happy inventor who shall teach manufacturers how to restore old india rubber to the condition in which it was before vulcanisation, for, with that secret, there would be practically *no consumption* of this invaluable article. The thing has been done, and successfully, and an American paper reports having seen pieces of vulcanised rubber possessing great strength and elasticity, which were made entirely from old car-springs; but it has never been accomplished on a large scale, and awaits the enterprise and ingenuity of some new Goodyear to develope it.

Meantime, old rubber has its uses. By a system of steaming and passing between rollers, it is reduced to a semi-plastic state, and in this condition is used in combination with a coarse fabric for heel stiffening, a purpose

for which it is admirably adapted, its waterproof qualities being of especial value. There is, in America, a factory devoted entirely to this branch of manufacture, where several hundred tons of old rubber of all kinds are consumed annually.

Old rubber is also largely used to mix with new raw material in the manufacture of all kinds of rubber goods. It serves to give bulk and weight, and if it does not increase, it certainly does not lessen, the strength of the fabric. It may also be mentioned that powdered soapstone, white lead, *terra alba*, and other heavy substances enter largely into the composition of almost all rubber goods, the use of which becomes apparent when it is remembered that they are generally sold by weight.

Waste rubber may be utilised by melting down waste clippings, &c., and dissolving the mass, when cold, in benzole or spirits of turpentine. The result is said to be an excellent varnish, which dries rapidly, adheres firmly to metals, and is well adapted for electrical apparatus. I have some doubts as to the asserted excellence of this varnish, but its qualities may be easily tested.

Tobacco Waste.—In France the refuse tobacco, consisting of waste and ashes from the government factories, is used for manure and for making sheep-wash.

In the very centre of the large tobacco warehouses in the London Docks there is a great kiln, familiarly known as the Queen's Tobacco-pipe, which consumes as "waste" an enormous quantity of articles. The fire of this furnace never goes out, day or night, from year to year. There is an attendant who supplies it with its fuel as it can take it, and men, during the day-time, are constantly coming laden with great loads of tobacco, cigars, and other valuable merchandise condemned to the flames.

Whatever is forfeited, and is too bad for sale, be it what it may, is doomed to the kiln.

At the other docks damaged goods are buried till they are partly rotten, and then taken up and disposed of as rubbish or manure. Here the "Queen's Pipe" sucks all up, except the greater quantity of the tea, which, having once set the chimney of the kiln on fire, is now rarely burnt. And strange are the things that sometimes come to this perpetually burning furnace. On one occasion the

attendant informed us he found nine hundred Australian mutton hams. These were warehoused before the duty came off. The owners suffered them to remain till the duty ceased, in hopes of their being exempt from it; but this not being allowed, they were left till so damaged as to be unsaleable. Yet a good many, the man declared, were excellent, and he often made a capital addition to his breakfast from the roast that for some time was so odoriferously going on. On another occasion he burnt thirteen thousand pairs of condemned French gloves.

In one department of the place often lie many tons of the ashes from the furnace, which are sold by auction by the ton to gardeners and farmers as manure, and for killing insects, or to soap-boilers and chemical manufacturers. In a corner are generally piled cart-loads of nails and other pieces of iron which have been swept up from the floors or have remained in the broken pieces of casks and boxes which go to the kiln. Those which have been sifted from the ashes are eagerly bought up by gunsmiths, sorted and used in the manufacture of gun-barrels, for which they are highly esteemed, as possessing a toughness beyond all other iron, and therefore calculated pre-eminently to prevent bursting.

Gold and silver, too, are not unfrequently found amongst these ashes, for many manufactured articles if unsaleable, are broken up and thrown in. There have sometimes, indeed, been vast numbers of foreign watches which, professing to be genuine gold watches, but discovcred to be gross impostors, have been ground up in a mill and then flung in here.

Such is the Queen's Tobacco-Pipe, unique of its kind and in its capacity of consumption. It is *the* Pipe, and establishes the Queen of England, besides being the greatest monarch on the globe, as the greatest of all smokers—not excepting the Grand Turk or the Emperor of Austria, the greatest tobaeconist of Europe.

Waste from Textile Manufactures.—When we consider that, in 1870, 600,000 tons of cotton, 119,000 tons of jute, and 174,000 tons of flax and hemp were imported and worked up here besides about 25,000 tons of home grown flax, one would suppose there ought to be a great deal of the waste of these materials and fabrics available for

the paper-maker. But among the minor tendencies of industries few are more noteworthy than that shown in the increased utilisation of waste materials. As competition becomes sharper, manufacturers have to look more closely to those items which may make the slight difference between profit and loss, and convert useless products into those possessed of commercial value.

Our manufacturers have not been slow to appreciate this truth, as is shown in more than one branch of trade. Thus the refuse waste from the spindles and looms of cotton-mills, which was formerly available for the paper-maker, is now found to possess a high textile value, and forms the basis of a distinct branch of trade. Millions of pounds of this waste cotton are used annually in the fabrication of wadding, cotton-wicks, common carpets, counterpanes, twine, &c.

Cotton Waste is the refuse cotton of the mill in the process of manufacture, being the "strippings" from the cards after the cotton has passed through the machine, the "flyings" or the portions which fly off from the card whilst the machine is in motion, the "droppings" and "blowings" which collect under the blowing-machine in which cotton is cleaned, and the "sweepings" or gatherings from the floor of the card-room. The value of cotton waste varies with the price of cotton; strippings and blowings are worth about one-half to two-thirds that of cotton; and droppings, blowings, and sweepings, one-tenth to one-eighth.

The actual quantity of this waste must be very considerable in this country upon a consumption of nearly 16,000,000 cwts.

By some authorities the waste in working is estimated at 15 per cent.; others set it down at 2 ozs. in the pound. The transactions in this cotton waste give employment to about 500 dealers. Oldham may be considered the headquarters.

In cotton waste spinning five or more different classes or qualities of waste are manufactured into yarn from the raw state or "mixing" to the finished product. The yarn of No. 1, the best after being sized, is used for the backing of tapestry-carpets. These carpets are also made with 3-fold 8's cotton worked as a warp with the waste yarn.

No. 2 is another description of waste, which goes through the various processes in spinning into yarn or roving. When bleached it is made into cotton counterpanes, and the yarn is also sold for candlewick in balls and bundles. Nos. 3 and 4, lower descriptions of waste again, are largely used for counterpanes, candlewick, braces, and many other manufacturing purposes; while there is still further a combination of the refuse of the preceding qualities which is worked over again and dyed black, as it will not bleach well or take light colours.

Jute Waste.—The trade in this fibrous substance has risen into enormous importance. It is the product of the *Corchorus capsularis*, and the culture is chiefly confined to Bengal. In this country the manufacture centres in Dundee. Jute is woven in India into gunny cloths and gunny bags, which are chiefly used in the Southern States for cotton packings, but in the United Kingdom it enters largely into carpets and many kinds of tissues. The imports into North America were, in 1872, upwards of 10,000 tons, which were sold to the Cotton States for about one million sterling. The manner in which the jute trade of Calcutta continues to increase is most remarkable. In 1863 the exports were only about 800,000 bales, and ten years earlier scarcely 20,000 bales were exported. In 1872 the shipments of jute and jute cuttings slightly exceeded 2,000,000 bales. Of this quantity the United Kingdom took about 1,500,000 bales, America 450,000, and the Continent 14,000. America also took three-fourths of the jute " cuttings," in which there is now a considerable trade. But even these large figures do not represent the total quantity of jute produced and brought to market, for besides a considerable quantity of jute consumed locally, upwards of 106,000 pieces of gunny cloth, and 28,500,000 of gunny bags were also exported during the year from Calcutta. The waste from the manufacture of the 200,000 tons of jute now worked up here, independent of the old bagging is necessarily large, and has only lately begun to be utilised to any extent.

During the memorable cotton famine the jute trade received its chief impetus; and the high prices then realised led to the inquiry for inferior qualities, down to waste. Accordingly the entire jute plant came to be supplied in

the various forms of best, seconds, and "cuttings;" the cuttings being chiefly composed of the root portions, on which there is a skin of much the same texture as beech-tree bark. These cuttings were bought up eagerly by spinners, who thought that with water-soaking the heckling and carding machines would take the fibre from the skin. In this they were disappointed; the skin after water-soaking being as tough as ever; the heckling-machines tearing the fibre to shreds, and the carding-machines, in turn, being blunted or destroyed. At once cuttings were rejected; from a relatively high price they declined to 5*l.* a ton; and from 5*l.* a ton they, for a time, became unsaleable. But the available supply of cuttings being large, the prices of cotton and wool high, and, more important still, competition being close, cuttings were occasionally bought up with some spirit. Nor is the demand now only from our own spinners, but also from America, France, and Germany; each buyer in his own way stripping or trying to strip the tenacious skin. What expedients were resorted to will never be fully known, but the most common was "batching"—a Scotch term for the firing of the loaves in a baker's oven. To batch the cuttings, a long thin layer is spread upon the ground, which at intervals is well soaked with oil and water. The soaking of the first layer being finished, a second layer, and so on to a fourth and fifth, is placed upon it; each layer, in succession, receiving all the oil and water that it will take. From three weeks to a month is occupied with each batch, and the consumption of oil being great, the tow produced at heckling costs the spinner on an average, 18*l.* a ton, when he buys at 9*l.* And be it said, that at its best, batching is an imperfect process; some tough piece of skin being now and then encountered on which the oil and water has made no impression, and, as a rule, the yarn spinning with much unevenness. So arose the inquiry how jute cuttings were to be freed from skin; how, without injury to the fibre, that skin could be permanently softened if not removed. How, in other words, could the skin be taken as from a piece of holly; how could a Lisbon orange, or a Regent potato be fairly peeled?

Now a firm of business men found this out, and in so doing discovered a fortune. They take the bales, as

packed on the Indian jute harvest-fields, open them, tumble them into a kind of brewers' vats, and in two or three hours bring them forth again, the skin perfectly and permanently prepared for any heckling or carding process. But being in a wet, and, moreover, in a dirty state, when taken from the vats into which they were first plunged, the first thing to be done is to wash with bright water; and here, again, the appliances of the dilapidated brewery render good service. From the washing-vats to the wringing or squeezing-rollers, and from these last to the breakers or heckling-machines, is accomplished with the rapidity of quick, consecutive application. The product turned out, at the most, in four hours, from the time the original bales are opened, is the jute-tow in present use—good in colour, capable of bleaching, pliant and strong in fibre, needing only to be dried before repacking and sending out; and so effectual is the transformation process that the cuttings may be all root, all cabbage-stalk, positively with no particle of leaf. The veriest "jute rubbish" is reclaimed just as the most hopeless scapegrace may sometimes be. What, without such treatment, was only fit to rot upon the dunghill, or to be committed to the flame, is rescued to the higher purposes of flax mixture in sailcloth, of hemp mixture in cordage, of wool mixture in flannels, of silk mixture in silks.

The moral is, that oftentimes more is begotten of thought than toil. How the attention of those engaged in the work of transforming jute was first called to the subject must not be told, although, with "cuttings" into jute-tow, as in the case of the sewing-machine, a word intended for another caught the ear of a listener, who brooded over it, and in time gave it form. Who forgets the demand, first, for a substitute for rags in paper manufacture; next for a cotton substitute? Or who forgets the elaborate papers in the 'Journal of the Society of Arts,' and other scientific publications, directing attention to discoveries and to difficulties? Thus, how to separate the skin from the fibre of the jute plant may have presented itself to those who have succeeded in the discovery, as a means of making money both plentifully and rapidly. No doubt they burned the midnight oil in researches and in tests. No doubt they devised one mechanical contrivance after another, which

in turn was doomed to be broken up by the scrap-iron buyer. Their success in a matter of so little promise, their triumph in a field where there is neither exclusiveness nor prohibition, is an encouragement equally to the humblest as to the highest to exercise their perceptive faculties, even under circumstances where there is no apparent connection between means and end.

The formerly despised jute "cuttings" are now purchased by some of the pressers in Bengal, merely to keep the screws at work all the year round, and are sent at an enormous profit to the United States, where the fibre is cleaned and worked up into an excellent paper.

The manufacture of whisky from jute ends has been tried by subjecting them to the process of conversion into sugar with sulphuric acid, and afterwards fermenting. The product has much resemblance to grain whisky.

Among the jute waste which goes to the paper-maker I find the following enumerated by waste dealers:—jute-ropes worth 9*l.* per ton; jute cuttings, 9*l.* 10*s.*; new jute-cloth cuttings, 10*l.* 10*s.*; jute spinners' waste, 8*l.*; clean jute threads, 9*l.*; jute card waste, cleaned 9*l.*, and uncleaned, 5*l.*; best jute caddis, 5*l.* 5*s.*; ordinary caddis, 4*l.*; best croppings, 6*l.* 10*s.*; coloured jute waste, 6*l.* 15*s.*; and old bagging, 7*l.* 10*s.*

The 'Dundee Advertiser' of the 14th May, 1873, was printed on paper made from jute, and in its issue observes:—"This is the first paper, as far as we are aware, ever printed on jute. Being in the centre of the jute manufacturing district, we have been anxious for some time to print on the material which has now become the staple of our local manufactures, and we are indebted to our principal paper-maker, Mr. D. M. Watson, of Bullionfield, for carrying out our wishes. It may be explained that this sample is made almost entirely from old jute bagging. We purpose to have samples made entirely from jute fibre. To some extent jute-bagging and waste have been used by paper-makers for several years, mixed up with other materials, and when we mention that nearly 50,000,000 of jute bags were exported last year (from Calcutta)—the demand for home requirements being also very large—it will be seen how large a quantity of manufactured jute there is to work

upon, especially as bagging is only one class of the goods made from this material.

"As newspaper publishers are too well aware, the price of paper has been seriously advancing, and one of the reasons alleged for the rise is the scarcity and consequent high price of esparto-grass. Now the supply of jute is practically inexhaustible. The importations into the United Kingdom have risen in less than forty years from 500 tons per annum to upwards of 202,000 tons. Instead of there being any sign of the importation falling off, the quantity at sea and in warehouse is greater than ever before.

"The jute fleet between Calcutta and Dundee is, perhaps, the largest fleet of sailing-vessels sailing between any two ports. Then the conditions under which jute is grown are favourable to the supply being increased almost without limit. The jute-growing region in Bengal is of vast extent, annually inundated by the overflow of the Ganges, Brahmaputra, and Migna, producing abundant crops with little labour, and yet that labour is exceedingly cheap and plentiful, the population being among the densest in the world. The water communication is so pervading and accessible that the crop is easily conveyed to market, and the facilities for shipment at Calcutta are unsurpassed. Such are the capabilities of the jute-growing districts that we have no doubt half a million of tons could as easily be sent to this country as 200,000 tons. There need be no fear of a demand for paper-making seriously raising the price of jute. It would rather benefit the importers were such a demand to grow up at present, since the market may be said to be glutted.

"We are now printing on paper made from jute after being manufactured. We intend to print on paper made from jute fibre, and if we show—as we are confident we shall show—that a first-rate quality of paper can be made both from jute fibre and manufactured jute, we have no doubt that the price will come all right. For some time jute cuttings have been used to a considerable extent by American paper makers, and as the American tariff favours cuttings, in order to benefit under it, the jute fibre is purposely chopped by thousands of tons into 'cuttings' in Calcutta. The class of jute which will probably be found most suitable for paper making in respect of cost and pro-

duction is that known as 'rejections,' which can be bought in any quantity in Dundee at 9*l.* 10*s.* per ton. That, no doubt, is somewhat dearer than esparto, but while the outturn of paper from esparto is only about 50 per cent., that from jute may be taken at 70 per cent., so that the yield more than compensates for the difference of price. We are satisfied, therefore, that it is for the interest of all connected with the paper trade to make trial of jute as a material for paper-making, and to show that we are not theorizing, but have full confidence in results being obtained advantageous to ourselves, and newspapers, and the public generally, we hereby offer 50*l.* for the best ream of paper made entirely of jute, and of which the maker will undertake to supply 50 tons at a price not exceeding 4¼*d.* per lb., and 100*l.* for the best ream of which the maker will undertake to supply 100 tons at 4*d.* per lb. The specimen reams to be delivered before the 1st of September, 1873.

"The immense and rapid development of the jute manufacture thus far shows what can be accomplished with a low priced and plentiful material. Why should not paper-makers, printers, publishers, and the public participate in the benefit of that material as the future staple of the manufacture of paper?"

An "Old Paper Maker," writing to the American 'Paper Trade Journal,' says:—"After several years' experience in using bagging and jute, in all its various forms, I am satisfied that it is the cheapest, cleanest, and easiest wrought of any substitute for rags, and that it possesses the very qualities most needed in straw paper; viz. a soft, tough fibre, that will remove the harsh, husky feeling of the straw, and render the soft, raggy feel, so much desired. This the jute does, and gives to the paper all the qualities of rag paper at much less waste and cost. There is no difficulty in boiling and bleaching the butts, if only lime is used in boiling (no soda ash or caustic can be used without turning the fibres red); say about 400 lbs. to the ton, and a pressure of say 25 lbs. in boiling. They should lay in heaps for a week after being boiled, and will then work as easily as ordinary rags, and will bleach much easier than many of the foreign rags now offered in market. The low cost and immense quantity now offered, with the large

yield of 63 per cent., make them decidedly the cheapest stock ever used, and I am satisfied they only need a trial to convince any good practical paper-maker of their success. In working them it is better to run them through a duster from the cutter, as much of the bark will fall off; but, what is still better, to run them through an opener, like the devils used for cotton waste, as this frees them entirely from bark, and leaves them in better condition to boil. They require less power to beat them soft, and when mixed with straw, in the proportion of one of jute to two of straw, will make a tough, clean print, hardly surpassed by the ordinary rag news."

Under the name of "junk," old and condemned pieces of rope and cordage, cut into short lengths, are used for making rope mats, swabs for ships' use, and oakum, which is the rope-yarns picked to pieces, and largely employed for caulking and other purposes. Oakum used to be picked a good deal in workhouses by paupers, but is now torn up by machine. During the Franco-Prussian war it found a large sale under the name of "marine lint" for surgical purposes. This and charpie, or torn-up lint, could scarcely be obtained in sufficient quantities to meet the demand for the wounded. Old rope is also much used now for making coarse paper.

A saving is about to be effected in the ropemaking at the dockyards by turning to profitable account the refuse from the hemp. Some 5 per cent. of the hemp used in the ropery at Chatham dockyard became useless by its conversion into dust and refuse in the course of manufacture; and the consumption of hemp annually in Chatham yard is 1100 to 1200 tons. This refuse has hitherto been burnt as useless; but it is understood that an offer has been made to, and accepted by, the authorities to purchase this refuse at 11*l*. per ton, it having been found that it can be used in the manufacture of paper.

Tracing paper of the best kind is made from the refuse of flax-mills, and prepared by the engine without fermentation; it thus forms semi-transparent paste, and affords transparent paper.

One of the largest manufactories of book-binders' boards in the United States, and probably in the world, is that of W. O. Davey & Son, on Jersey City heights, opposite New

York city. The refuse of an oakum factory, which forms part of their establishment, and tarred ropes, which cannot otherwise be utilised, make up the hard stock. The ropes are cut into pieces by a machine like that used in machine-shops for cutting short iron. The stock is not washed in engines, but ground on elbow-plates arranged in an effective and improved apparatus. Three cylinder machines are supplied, on which the pulp is transformed into boards of almost any thickness, which are afterwards subjected to five or ten minutes' pressure in a hydraulic press. The boards are then placed in a peculiarly constructed heater, which consists of a number of flat hollow plates of metal, in which steam is admitted, and between which the boards are arranged and allowed to remain until nearly dry. They are then removed to a drying-house which is warmed by steam pipes, and afterwards calendered. About four tons of boards per day are produced at the above mill. Straw boards, which are now applied to a great number of uses, particularly for paper car wheels, are formed, dried, and cut on machines like ordinary paper. A very hard variety of boards is manufactured partly from leather clippings. The leather for this purpose is cut into small pieces like rags, reduced in the engine with about the same quantity of bagging and waste paper, and made into boards on a cylinder in the ordinary manner. The boards acquire the appearance, and to some extent the properties; of leather. The material requires considerable time for washing and grinding, and size is unnecessary in its manufacture.

Roofing paper is made principally from woollen rags, mixed with a sufficient quantity of hard stock to give it the necessary strength. The material used is of a porous nature, and its quality depends upon the amount of tar or similar substance that it can absorb. Most of the processes of its manufacture are protected by patents.

Parchment paper is made from unsized rag paper, the cellulose of which changes its nature if it is for a short time immersed in diluted sulphuric acid, and then again well washed; it becomes tough, waterproof, and transparent, like animal parchment.

Tobacco paper for cigarettes is produced by mixing Manilla fibre with liquor in which tobacco stems have been

previously boiled. It burns when dry with a white ash, like a tobacco-leaf, which it resembles closely. Cotton waste yields from 30 to 50 per cent. of paper of an inferior quality, principally used for blotting. Manilla fibre is the strongest known; but the supply is small, and the so-called Manilla paper is often made from the butt ends of jute or jute cuttings.

An imitation Manilla paper is sometimes made from old wrapping paper and straw, coloured with Venetian red in the engine. The paper used for paper collars, of which there is so great a consumption, is cotton and linen, with a large admixture of the former.

Hemp bagging and a small proportion of cotton canvas are used for tissue paper, the fibres of which are very strong. For bank-note paper only the best of white linen is used. The dried paper is passed through animal size, and the sheets are pressed between fine pasteboard to give them a dead finish.

There are a hundred opportunities among the staple industries of this country to secure an equal economy and profit, by turning to proper uses residues and substances now disregarded and thrown away as waste.

Waste Substances for the Paper Manufacture.—First and foremost of the many applications of the humble material old rags, is the manufacture of paper. Cotton and linen rags are sorted with equal care. They are the principal source of papermaking material, and are in constant demand. Used alone, they make the highest grade of paper, while, in combination with varying proportions of paper stock, they produce the different grades of paper to be found in the market. Paper material may be used over and over again, provided always that a given amount of new rag stock is used, but it deteriorates in value with each process, owing to the breaking and consequent shortening of the fibre; and, beginning, say in the form of writing paper of fine quality, it passes successively through the various kinds, and eventually is found in the shape of a coarse article, possessing little strength and small value.

The following classification shows some of the names under which rags pass:—Fines, outshots, seconds, blues and checks, light fustians, light prints, thirds, black cottons, hemp bagging, new Botany bagging, clean Surat bag-

ging, common sheeting, coloured Surat carpeting, rag ropes. And the following also are worked up again :—Best brown top papers, mixed coloured papers, printers' papers, envelopes, books, paper shavings, &c.

Fines consist of such goods as clean white linen or cotton shirts, &c.; seconds, of dirty or soiled white garments, as linings of ladies' dresses; thirds, of corduroys and similar articles, colours of printed cotton pieces. New pieces consist of new material, as collars, shirts, &c., and with these in value may be classed the ends of cotton pieces; canvas from the royal and commercial navies also meets with a ready sale for paper-making purposes.

The price of rags mainly regulates the price of paper, for these are the mainstay of the paper-maker, although now supplemented to a small extent by crude vegetable fibres. The comparative scarcity of rags and kindred substances have rendered their supply as the main article for paper-making more and more inadequate; while the importation of esparto fibre from the Mediterranean countries has likewise failed to meet the augmented demand.

The average value of the rags and other paper-making materials imported in the year 1871 was 1,776,293*l*. The total quantities for five years are shown in the following return, in tons:—

	1867.	1868.	1869.	1870.	1871.
Linen and Cotton Rags	19,201	17,902	17,027	22,394	26,868
Esparto and other Vegetable Fibres	55,972	96,539	89,156	110,389	154,357

Since the discovery of a method of separating ink from printed paper, old newspapers and old books have entered largely into the paper-makers' material. And the lesson of economy should be learnt, to save for market the waste paper, instead of kindling fires with it and casting it to the winds. Let frugal housewives take a hint, and add the wasted hundredweights of old paper to the great civilising agent of the present day.

The import of foreign rags suitable for paper-making

has increased in the last ten years by more than 50 per cent. For twenty years it averaged about 10,000 tons. In 1858, it was 11,379 tons, value 246,133*l.*; in 1871, it was 26,868 tons, value about 444,000*l.* The aggregate quantity of rags annually collected in the kingdom, with those imported, may be taken at about 90,000 tons weight, worth at least 1,500,000*l.* It takes 100 tons of rags to make 70 tons of paper; the make is now about 134,000 tons annually. Notwithstanding the rags produced by our population of 30,500,000 inhabitants, added to the large quantity of jute-bagging, linen and cotton wrappers, old sails, cordage, &c., it will be seen that we are largely dependent on foreign supplies of waste materials for our paper-mills.

In this utilising age it cannot reasonably be expected that a waste product such as rags, which has been proved to possess a length of staple, when broken up, sufficient for the spinning of common stuff, will be much longer permitted to find its way exclusively to the paper-mill. Like flock and shoddy, linen and cotton rags will be taken more and more from the paper-maker, and raw vegetable fibres will have to be sought for or cultivated.

Wild Vegetable Substances that can be utilised.—Chemistry has taught us that the cellulose of all plants is the same as that contained in rags, and that, in fact, the fibre of some plants will give us a paper that cannot be made from rags. Not all plants, however, are adapted to the making of paper. Much depends upon the bark, membrane, and fibre; and there is a difference in the purity of the cellulose of various plants. Chemical tests also show a modification in the fibre of plants.

M. Bernstein, of Odessa, speaking of the paper-producing plants in Southern Russia, states that there are in the Government of Kherson about 200,000 acres of land annually cultivated with flax solely for the seed. On the average of ten years' crops one hectare produces 50,000,000 lbs. of stems, or refuse material, which is generally employed as fuel, used as thatching, or left to rot, in consequence of the considerable distance it is from the linen and paper mills.

M. Pitancier, who gained a medal in 1851 and two in 1862, at London, for the chemical products of his manu-

facture, recommends the reduction of the flax into pulp. He states that there are also other vegetable products in Southern Russia of far greater value to the paper-maker than the waste flax, and calls attention to the straw of various kinds, and the leaves of maize. The reeds growing on the banks of rivers he has ascertained by experiment yield nearly 50 per cent. of their bulk as materials for paper. The rush is almost as rich; and the paper produced from these plants is strong, lustrous, and even.

For many years it has been pointed out that an endless variety of cheap materials exists in British tropical dependencies, admirably suited for paper-making; but the ever recurring difficulty is, not where to get it. nor even what to get, but how to induce anyone to bring it; or if brought, how to induce anyone to be the first to use it. This want of spirit is the dead weight which presses so heavily on the paper manufacturer.

Various attempts, which have been made from time to time, to introduce new raw materials for paper, have been attended with but partial success. The failure generally results from one or more of three causes.

1. Some fibres require so much cost to bring them to the state in which they are usually offered to paper-makers, in the form of rags or cotton waste, that in point of economy they cannot enter into competition with the latter.

2. Certain fibres lose so much in weight in bringing them to this state, that they cease to be economical.

3. Certain fibres, which are well adapted on account of their texture for the paper trade, present so many difficulties in bleaching them, as to render them unfit for white paper.

Only three or four new waste substances have as yet come largely into use for the supply of the paper-maker—straw, esparto fibre, wood pulp, and the bamboo. Straw is very largely utilised for paper.

Esparto Grass.—The enormous trade which has sprung up in the wild grass, known under the name of esparto, for paper-making, is an instance of the utilisation of a waste or neglected vegetable fibre. This coarse strong grass—the *Stipa tenacissima* of Linnæus—growing in tufts, resembling, in the cylindrical form of the stalk, rushes, has

only come into general commercial use in the last twelve years. In 1851, specimens of the fibre and of paper made from it were shown in the Algerian department of the Exhibition; but our paper-makers ridiculed it, until a dearth of rags drove them to look for some material which might be employed. On the 28th of November, 1856, the number of the Society of Arts 'Journal' containing Dr. Forbes Royle's paper on Indian fibres, was printed on paper made from esparto, by Mr. T. Routledge. The extensive use of esparto has furthered the cause of literature by furnishing a raw material for paper, and at the same time supplied a want of which our shipowners had long complained—return cargoes from Spain and Algeria.

The general use of esparto by British paper-makers—which has been imitated by only a few millowners in France, Belgium, and Germany—is but another proof that our countrymen, when once the truth of a theory is demonstrated, can carry it out practically. In 1856 some 50 tons of esparto were imported. The trade made such good use of it, that in 1861 no less than 8000 tons were brought to the United Kingdom. From that time the import rapidly increased. In 1862 it amounted to 12,000 tons; and in 1865 the ports of Almeria and Carthagena alone shipped 50,000 tons. Then the African fields added their quota, and now the arrivals reach the enormous quantity of nearly 130,000 tons. In 1871, 59,589 tons were shipped from Algeria, valued at nearly 300,000*l.*

It is greatly to be regretted that both in Algeria and Spain, instead of mowing the esparto at the proper season, the natives pluck it up roots and all in the most reckless manner; and they are thus destroying the grass by their method of gathering it. In Algeria new regulations have been issued, prohibiting the gathering before April. The progress of civilisation would almost appear to be the occasion of waste and destruction. For here is an instance of natural production being wantonly destroyed by man, in spite of his deriving a benefit from it. The value of the dry grass on the spot ranges from 5*l.* to 6*l.* per ton, and under favourable circumstances, as much as 6 to 8 tons can be obtained from an acre.

Straw Paper.—One of the best articles of this description is made by the Manchester Paper Manufacturing Company,

near Poughkeepsie, New York. Rye-straw, delivered by farmers from the adjoining country in perfectly clean bundles, is exclusively used. It is first chopped in pieces of about three-fourths of an inch in length, by means of a cutter, during which operation all weeds and impurities are removed by hand. Cleaning, to get rid of grain and dust, follows, and then the straw is passed through a pair of heavy iron press rolls, which open out the tubes and knots. It is then passed into horizontal rotary boilers, in each of which is 60 gallons of a solution of caustic soda for every 100 lbs. of straw. These boilers are walled in, heated by direct fire to a pressure of about 60 lbs. above the atmosphere, and kept so for six or eight hours. The stuff is discharged into a tub with a drawer bottom, where the liquor is washed out, and thence to a chest serving as a reservoir to a Kingsland engine, in which any knots or bundles of fibre, which may remain, are completely removed. It is then conducted into drainers, where it remains until dry, when it passes to an ordinary washing engine, in which it is re-washed, bleached with a solution of chloride of lime, and sent to a second set of drainers. Mixing with size, colour, and clay follows, then another passage through a Kingsland engine, and, lastly, the material is run over a Fourdrinier paper machine.

The paper made by this process is soft, clean, and white, and finds a ready market for book printing. Since the works of the company have been reconstructed, superheated steam is used instead of direct fire in the boilers. Nearly 50 per cent. of paper from straw and 60 per cent. from esparto is obtained. This is a very extraordinary yield, as it is the experience of many manufacturers that not over 33 per cent. of good white paper can be obtained from straw in the rough condition in which it is received at the mills. There are but two ways in which 50 per cent. of white paper can be obtained from straw alone; either by the production of paper of inferior quality, containing much of the inter-cellular matters, or by not counting the clay and size which have been added in sufficient quantity to make up for the lost fibres.

Wood pulp for paper is now very largely employed. The suggestion of the applicability of wood fibre to paper-making is by no means new.

Early in 1826, the brothers Cappueino, paper-makers of Turin, diseovered the means of supplying the want of rags by the fabrieation of paper from the thin bark of the poplar, willow, and other kinds of wood. The Academy of Seienees having examined the speeimens of writing, printing, and wrapping paper thus produeed, acknowledged their goodness, and praised the inventors. The King granted the inventors an exclusive privilege for ten years for the manufacture of paper from ligneous materials.

In 1838, James Vineent Desgrand took out a patent in this eountry for making paper and pasteboard with wood, reduced into a state of paste ; and of the different sorts of wood that came under the denomination of white woods, he found poplar answer the best. In 1855, William Johnson was granted a patent for improvements in the applieation of various substanees containing woody fibre to the manufaeture of white paper pulp, as the inner bass of the lime-tree and other *Tiliaceœ*, the willow, bireh, and elder.

Partieularly faeetious persons have more than onee informed us that sawdust is a highly nutritious artiele of diet when properly cooked ; but uses have been found for it other than gastronomieal, one being as a fibre for paper-making. Wood of any kind or age is equally well adapted for this proeess, whieh is being extensively worked in some of the Continental States. At the London International Exhibition of 1862, Wurtemberg eontributed several samples of paper made from wood-pulp mixed with rags, the proportion of the former varying from 10 to 80 per cent. ; and the paper was reported to be serviceable, although of a low quality. The wood was simply rubbed down into pulp against the periphery of a wheel prepared with a rough face, so utilising the enormous waste of the timber-produeing forests of the north of Europe. A good rule, equally applieable to the manures of the farmer and to the supply of the paper-making material, I would give in a few words:—Use what others waste. If the thousands of tons of sawdust annually wasted at the different saw-mills in Ameriea and Europe eould be eolleeted, there would be no want of material for paper of a certain quality. But as this eannot be done,

we may fairly suppose that, in some localities, an abundant supply may be obtained: if not, resort must be had, provided that the wood itself is cheap enough, to mechanical means of disintegration.

Eight or ten years ago, the Americans went into the manufacture of paper from wood, the Manayunk Wood Pulp Works, Pennsylvania, being established on a large scale.

The works of this paper company are capable of making fifteen tons of white-wood pulp per day. The material is brought to the works as cord wood of five feet length. It is first cut into thin slices of about half-inch thickness, and then by large steel knives chopped into small pieces, forty cords being thus treated daily. The material is then boiled with a solution of caustic soda in upright boilers, heated by steam circulated through a jacket, and in which it is confined between perforated diaphragms. To every two boilers is connected by a capacious pipe a large sheet-iron cylinder, which receives their contents—pulp, liquor, and steam. The liquid solution of pulp flows from these receptacles to flat iron drainers mounted on wheels, each of which is large enough to hold the contents of one boiler. The trucks on which these cars run are underlaid with sewers which receive the liquid as it drains off from the pulp. The latter then goes to washing engines, thence to stuff chests, and from there is forwarded by pumps to wet machines, the screens of which retain all impurities derived from knots, bark, and other sources; and the pulp or half stuff so obtained is perfectly clean and of a light grey colour. It is bleached in engines with a solution of bleaching powder—like rags—emptied into drainers, and kept there from 24 to 48 hours.

It may appear to the uninitiated that the expense of the enormous consumption of alkali involved in this process would be fatal to its commercial success; but, fortunately, no less thon 85 per cent. of the alkali is recovered after every boiling, to be used over again with 15 per cent. of fresh alkali on a new supply of wood. To recover the alkali, the liquor drained from the pulp is collected in drains under the floor of the boiling-house, and thence conducted by underground pipes to the evaporating-house, whence it flows through evaporating furnaces subject to heat both above and below.

The finished pulp is of soft white spongy fibre, and, mixed with rags, is worked into book and fine printing paper. Poplar furnishes very white fibre, and is preferred to other woods. Its fibres are, however, short, so that it is often found expedient to mix them with those of spruce or pine. The percentage of pulp in different kinds of woods varies, hemlock-spruce (*Abies canadensis*) yields 45 per cent., the largest proportion; then dry walnut, 42 per cent.; and least of all, lignum vitæ, 15·8, and ebony, 14 per cent. About 28 per cent. from young, and 30 per cent. from old, poplar wood (one cord of which weighs from 2800 to 3400 lbs.) is obtained at the Manayunk works.

After the materials for paper-making are dusted and sorted, the next process is the extraction of ink and fat by boiling. Writing ink can be extracted with water alone, but a solution of soda is required for printing ink.

There are now more than thirty paper-mills in Germany working up wood pulp, and there is not a journal published there which does not contain more or less of wood pulp in the paper used. At the Paris Exhibition in 1867, was to be seen in action one of the large machines of 50-horse power, constructed by Decker, Brothers, and Company, working the process of Mr. Henry Voelter, of Heidenheim, Wurtemberg, for making wood pulp for paper. The exhibitor, who was the first to carry on the manufacture, has developed it on a large scale, and greatly reduced the price of all kinds of paper by introducing from thirty to sixty per cent. of wood pulp into the substance. He also exhibited a very large collection of various kinds of paper made from wood. All white woods are available for this purpose.

The range of choice of wood for paper-making is by no means limited; the pine family contributes, however, most largely to the manufacture. But another question of economy arises, which has excited much inquiry and invention, namely the most advantageous method of reducing solid wood to the requisite degree of fineness for subsequent treatment.

The first mode of preparing wood pulp from the pine and other white woods, was to reduce it into thin shavings, which were soaked in water for six or eight days, and then dried or ground to powder by a corn or crushing mill.

This powder was mixed with rags so as to make a pulp, and the ordinary operation of paper-making was then proceeded with. The principal defect of this material was the shortness of the fibre.

Wood pulp, chemically produced, although undoubtedly good as to quality, labours under the disadvantage of being too dear; but its production by mechanical agency, which is much less costly, may now be considered as brought to great perfection by means of improved machinery, amongst which Voelter's system claims an undoubted superiority, at any rate in localities where the raw material is abundant enough to afford supplies for their great converting capacity, and its action is facilitated by a sufficiency of water-power. Under such conditions, each one of M. Voelter's engines of the ordinary size is capable of producing 17 cwts. of pulp daily, at a cost varying in proportion to the nature of the motive power employed, the price of the raw material, the facilities of transport, the rate of wages, and other contingencies.

In all these respects, Sweden (according to a detailed report of Mr. Gustaf Josephson) offers peculiar advantages. The supply of soft pine wood, perhaps the most suitable of all for the manufacture of paper pulp and pasteboard, is there practically unlimited, and obtainable at a price of 1½*d.* to 2*d.* per cubic foot, whereas in Germany, where a number of such works have been in existence for some time, and have supplied English markets with their produce, which is, however, mostly of inferior quality, the same material is worth about 3*d.* per cubic foot on an average. Aspen wood is likewise plentiful and cheap in Sweden.

There are now about 160 of these wood-pulp machines at work on the Continent. Some of those in Germany and Belgium, and about thirty of those situated in the Scandinavian countries, where material is abundant, send their pulp to England as a paper-material.

The subsequent difficulties in developing wood pulp have been the large quantity of alkali required for disintegrating the fibre, and the necessity for very strong vessels in which to perform the operation, because it was by boiling at a high temperature with a solution of caustic soda, that this could alone be performed.

Uses of the Bamboo.—Among the waste vegetable substances that have been brought into use by the paper-maker, is the gigantic grass the bamboo. The bamboo has been devoted to the service of literature as long as the papyrus itself. More than two thousand years before the Christian era, the conquerors of China signalled the establishment of a new dynasty in the Flowery Land by a conflagration of the national records. These documents were written on plates of bamboo. How far they went back, takes us almost beyond the flood! The dynasties of Yu, Chang, and Chea had inscribed their records on bamboo plates for a thousand years before their barbarous destruction under the reign of the Tshin kings. Books of this primitive nature may be seen among the curiosities in the King's library at the British Museum. But to use the plant, not as wood, but as paper, to tear asunder the durable and jagged fibres, only that they may be felted together in a finer and closer union—to supersede the toil of the *chiffonnier* by that of the cane-cutter—is a new application of an old material.

This plant, which grows abundantly throughout the length and breadth of Jamaica and others of the West India islands, has been for some time past exported to the United States, in bales and bundles, for the purpose of being manufactured into paper; and has proved itself for that purpose equally as valuable, if not superior to rags. The trade thus opened promised to have proved beneficial to the Colony, and remunerative to any party or parties who embarked in the speculation; the value of the bamboos now growing in Jamaica alone having been estimated as high as 150,000*l.*, and they are of very rapid growth. The difficulties, however, experienced in shipping them caused some fears that the trade in the article might soon be lost to the country. Made up into bundles of large dimensions, the hold of a vessel is very soon filled up; and from the light weight of the commodity, captains of vessels did not care to take it as freight, any vessel so laden becoming what is generally understood to be "top-heavy." To prevent this, the vessel had first to be stored with heavy cargo on her ground tier, therefore allowing less space for bamboo, and consequently reducing every shipment to the lowest remunerative scale as regards the

shippers. To obviate this difficulty, the bamboo is now crushed into fibre between the rollers of cane-mills, thereby saving more room in stowage, and as a result the means of making larger and paying shipments.

In the close of 1865 the 'New York Daily Tribune' was printed upon bamboo paper made by the Fibre Disintegrating Company, working at New Jersey, under a patented process of Mr. A. S. Lyman. The bamboo is subjected to high pressure in steam cylinders, which disintegrates the fibre and dissolves the silex. It is then boiled in waste or spent alkali in an open vessel, and afterwards purified and bleached in the ordinary manner in paper-making. The Fibre Disintegrating Company have large works at Red Hook, South Brooklyn, a factory at Elizabeth Port, New Jersey, and works at Carondelet, near St. Louis, Missouri.

At the London Exhibition, in the Liberian department, fibre was shown, taken from the external coating of the bamboo, which makes the strongest cordage of any material known to the aborigines. They use it for nooses in their snares for taking wild animals of the greatest strength. The fibre of the leaves is also extensively used by the natives for finer articles, thus hammocks are made with it.

The leaves are convertible into stuffing for mattresses, being as good as horse-hair after having been dried for only a few days. Beds which have been in use for the last nine or ten years have the leaves still in their pristine state, and are likely to continue so. There is no disagreeable or unwholesome smell in the leaves.

The American Fibre Disintegrating Company, of New Jersey, also make paper pulp from a species of wild cane which abounds on the banks of the Mississippi, also from hemp stalks. Not less than 100 tons of cane are roughly broken down daily to be sent to the paper mills. The price of the material delivered undried is said to be only 1*l.* per ton, and the cost of disintegrating but 5*s.* per ton, whilst the yield is one ton of paper pulp to five tons of the undried cane. A variety of other substances have been tried, but few drawn into use for the manufacture of even the coarser kinds of paper; still, even for these, the raw material is in demand, and substitutes for the finer flax

and hemp rags have been for some time much in request for the better kinds of writing paper.

Among the substances recently mentioned, a few may be enumerated as calculated to stimulate inquiry and promote experimental research :—

The sea ragwort (*Cineraria maritima*). Several very satisfactory results have been received from various paper-makers as to its great utility for trade purposes, and there is every reason to believe, if proper attention is paid to its cultivation, it will in time become a staple article of commerce among manufacturers. The seed, at present, is imported from France and the south of Europe, but preparations are being made for growing it on a large scale in the United States.

A new use has been found for the tules or reed-like vegetation that grows on the swamp lands of California. This plant is known to botanists as the *Scirpus lacustris*, and is claimed to yield from fifty to sixty per cent. of paper pulp equal to that obtained from cotton. If this calculation is based upon dried material, it may be correct; but it is not possible that it can hold true with reference to the green tules any more than it would to green maize-stalks. But there seems good reason to believe that the plant is capable of profitable use in paper-making, and it is to be hoped that the arrangements said to be under way for manufacturing on a large scale will be vigorously pushed.

The *Epilobium* is favourably spoken of for paper-making in North America. It abounds in the northern wilds of the United States and Canada, and hundreds of acres of the plant are to be met with in the northern woods of New York. It is vulgarly called "fireweed," from its springing up spontaneously upon evergreen timber lands that have been burnt over. The plant is perennial, and grows to the height of four to six feet, the stem being one-fourth of an inch in diameter, and some two feet from the top, putting out a dozen to twenty branches, upon each one of which there are from fifteen to twenty pods, these in August open and display a white fibre, essentially like that in the boll of the cotton plant. The seeds are very small and numerous, but, unlike those in cotton, require no ginning process to separate them from the fibre. The

plants grow very close together, and upon poor or rich soil, and in any climate from 40° N. to the Arctic circle. It has been found in nearly all the Northern States. Its southern limit of growth is the northern limit of cotton.

The Hon. Rutger B. Muller, of Utica, New York, states that he made candle and lamp wicks of this fibre, and ropes which bore as much weight as cotton ropes of the same size. Carded and spun, it made excellent yarn, from which a stocking was knit. It will make good batting, and the finest of paper, being almost equal to silk for this purpose.

The root is medicinal, and is prepared by the Shakers, who sell it wholesale to druggists for about 1*s*. 6*d*. per lb. The sap yields a milky substance like india-rubber.

Experiments in making paper from palmetto leaves and wire grass have been made for the last two or three years by Mr. Henry Banks, of Atlanta, Georgia. The 'Charleston News' states that last August he shipped 8000 lbs. to a paper mill in Philadelphia, and went there himself and witnessed the whole process of converting palmetto leaves into paper, which proved a greater success than his most sanguine hopes had anticipated. The palmetto paper is superior to that made of wood, straw, or rags, both in texture and cost of production, and will yield a profit of 50 per cent. to the manufacturer. Mr. Banks confidently believes that even a greater profit than 50 per cent. can be realised, the raw material costing from one-quarter to one-half a cent per lb., while rags will cost four and a half, and not make as good paper as the palmetto.

Owing to the increased demand for rags, it has been found necessary to employ other substances for mixing. Generally speaking, and especially as regards the grasses, these auxiliary pulps, however, do not fall very far short in price of the rag product, and thus, while by such admixtures the immediate demands are met, the cost of paper remains high, and acts as a check on that expansion of the paper manufacture which is one of the greatest and most urgent requirements of the times.

The paper-makers, much as they desire to obtain increased supplies of new vegetable substances adapted to their manufacture, are very slow to adopt any. Thus esparto was a very long time making its way into public

favour. There are, perhaps, excuses for the manufacturers to be found in the fact that they want substances which will not involve any necessity for the establishment of new machinery, or any great expense in chemicals for bleaching. They also desire to be assured of large and continuous supplies of any material found suitable.

Among the most promising additions lately, and which seems likely to become of importance, is a common Australian weed, the *Sida retusa*, which is very troublesome, from its luxuriance and coarseness, to the proprietors of sheep-walks. This fibre is superior to esparto, is clean, bleaches without the smallest difficulty, and the supply is said to be unbounded. Although the fibre and straw were favourably reported on at the Intercolonial Exhibition at Melbourne, at the London Exhibition, 1862, the Paris Exhibition, 1867, and the London Exhibition in 1872, little has yet been done to test it or supply it on an extensive scale.

There is no doubt about the enormous quantities of *Sida* that could be produced. It is often seen forming a dense solid mass of vegetation from four to six feet high, covering land that has been out of cultivation for but one season. It spreads with terrible rapidity, as farmers know to their cost; and in Queensland alone, tens of thousands of tons could be cut annually, if a price were offered that would pay for cutting. It is not confined to one Australian colony, but is very generally spread. It is found growing from one end of New South Wales to the other. If a reasonable price be obtained from the manufacturer, it could be produced in quantities to keep dozens of paper mills in full work. If not consumed in the few paper mills of Australia, it could be prepared as "half stuff," and shipped to Europe. But if it would pay the home manufacturers to purchase the half stuff, it ought to pay local manufacturers better to convert it into paper on the spot.

Surely, if it be found more profitable to make 30*l*. by an acre of weeds than 4*l*. or 5*l*. by the same quantity of wheat or maize, common sense would dictate, 'go in for weeds and buy the corn.

In some parts of France numbers of persons are employed in collecting thistle heads for paper manufacturers, who use them as a substitute for rags, but why not employ the

stem and all the plant. I have no desire to encourage the culture of this raw material here, however desirable it may be to collect the heads, and thus prevent the seeds scattering. But there is a very prolific field for collection on the Pampas of South America, where, according to Sir F. Bond Head, for 280 miles after leaving Buenos Ayres, the region is covered with them. Imports of these thistle-heads (*Cynara carduncuclus*), with the yellow down, have been made here, under the name of "vegetable wool:" but did not meet with any sale. Sir F. Head says, "In spring the whole region becomes a luxuriant wood of enormous thistles, which have suddenly shot up to a height of ten or eleven feet, and are all in full bloom. The road or path is hemmed in on both sides, the view is completely obstructed, and the stems of the thistles are so close to each other and so strong, that independent of the prickles with which they are armed, they form an impenetrable barrier." —*Head's 'Pampas.'*

Paper is manufactured from oat refuse by Mr. Hay, of Glasgow, by first immersing the oat-husks in water in a tank, in order to float off mustard and other seeds, with which they are frequently more or less mixed, and which, if not separated, materially deteriorate the quality of the paper. It is of advantage to have the water well stirred, as it facilitates the separation of the foreign seeds, and allows them to float to the surface. The oat-husks are then allowed to settle, and the surface scum and floating seeds are drawn off by an overflow pipe at the top of the tank, or skimmed off by a rake or other tool, or otherwise removed; after which the water is drained from the oat-husks by a waste-water pipe at the bottom of the tank, and beneath a perforated false bottom, or fitted with a strainer, which retains the oat-husks. The oat-husks may be left to steep in the water for from five to ten hours after or during the removal of the scum, as this steeping, by softening them and helping to loosen the silica from the fibre, facilitates the subsequent boiling process.

As far back as 1817, a patent was taken out in France to make paper with the residue of the potato, after starch making; in 1830, with the pulp of the beetroot; in 1834, with the leaves of trees, dog-tooth grass roots, and the stems of asparagus; in 1837, with the leaves of maize; in 1845,

with the leaves of the fir or pine; and under another patent, with spent hops, beetroot pulp, and potato pulp; and in 1855 the application of the fecula left in making starch from chestnuts, acorns, &c., was patented.

Uses of the Waste and Residues of the Maize Plant.—After wheat no cereal is so largely cultivated as maize. In the United States, the South of Europe, and Australia enormous crops are raised of it; and it is even found difficult, in some distant localities in North America, to dispose of the grain itself to advantage or with profit. Hence it is often burned for fuel in engines, stoves, &c. The production of maize in the United States now reaches about one thousand million bushels annually. At present there is little or no profitable vent for it in Europe. Russia, Turkey, and the Danubian Provinces can now undersell the United States. What, then, is done with all the Indian corn produced in the United States, now that there is little or no demand for Europe? It is not made into bread, for although the "corn crop" *par excellence* in name of the Great Republic, wheaten bread is the mainstay of the people there. It seems then to be chiefly given to hogs, and so converted into pork, or made into starch, and distilled into whisky.

During the revolutionary war in America, molasses was frequently made from the stalks of Indian corn, and while it could be kept from fermentation it was highly prized; but it soon became tart, an evil doubtless easily corrected by lime, as is now practised in all sugar factories. It has been ascertained that a bushel of Indian corn worked in a distillery gives over a pint of oil. It is easily purified, and burns with a clear bright flame. At a whisky distillery near Ontario, oil is extracted at the rate of 16 gallons per 100 bushels of corn, leaving the remaining portion of the corn more valuable and in better condition for distillation than before the oil was extracted.

The manufacture of alcohol has of late years reached a great development in the United States, and it is chiefly made from Indian corn. The grain is first subjected to a process of malting, or artificial germination, by which the starch it contains is converted into sugar. An infusion of this malt is then fermented with yeast, the fermentation consisting of the breaking up of the sugar into alcohol and

carbonic acid, which latter escapes in the form of gas. The alcoholic liquid is then distilled, and the first product, known under the name of "corn whisky," is re-distilled or rectified in stills of peculiar construction, by which it is reduced to the commercial strength of 95 per cent. of alcohol to 5 per cent. of water. Alcohol thus made always retains a nauseous odour and flavour, which is due to the presence of certain substances which approach to alcohol in their degree of volatility educed from the whisky.

The leaves and stalks of maize make good paper, and Cobbett's book on Indian corn was printed on paper made of this material long ago.

According to Dr. Schaeffer's 'Sammtliche Papier-versuche' (Reginsburg, 1772), two maize straw paper-factories existed in Italy in the last century. As early as the seventeenth century an Indian corn paper-manufactory was in full operation at the town of Rievi, in Italy, and enjoyed a world-wide reputation at the time; but with the death of its proprietor the secret seems to have lapsed into oblivion. The manifold attempts subsequently made to continue the manufacture were always baffled by the difficulty of removing the silicious, resinous, and glutinous matters contained in the blade.

In 1837 Edmund Shaw took out a patent in England for envelopes or sheathing leaves that cover the ears of Indian corn for making paper. This was not the first time that paper was manufactured from Indian corn leaves.

The recovery of this process is due to the research of one Herr Moritz Diamant, a Jewish writing-master in Austria. Having busied himself for some time in experiments on Indian corn, the ingenious discoverer was at length rewarded with the desired results of his labour; and a trial of his method on a grand scale, made at the Imperial manufactory of Schlögelmühle, near Glegnitz (Lower Austria), completely demonstrated the certainty of the invention. Although the machinery, arranged as it was for the manufacture of rag paper, could not, of course, fully answer the requirements of Herr Diamant, the results of the essay were extremely favourable. The article produced was of a purity of texture and whiteness of colour that left nothing to be desired; and this is all the more valuable from the difficulty usually experienced in the removal of impurities

from the rags. Knots, and other inequalities of surface, so frequent in the ordinary paper, and which give so much trouble in printing, the new product is entirely free from, and this without the material undergoing any special process to attain the desired end.

Another great advantage, and this in an economical point of view, is the reduction of the steam-power required in the manufacture by *one-third* of its present amount, in consequence of the material being reduced to pulp by chemical, and not, as at present, mechanical agency. Count Carl Octavio Lippe, of Wessenfeld, bought the invention from the originator, and from several experiments deduced the following results:—

1. It is not only possible to produce every variety of paper from the blades of Indian corn, but the product is equal, and in some cases even superior, to the article manufactured from rags.

2. The paper requires but very little size to render it fit for writing purposes, as the pulp naturally contains a large proportion of that necessary ingredient, which can at the same time be easily eliminated, if desirable.

3. The bleaching is effected by a very rapid and facile process, and indeed, for the common light-coloured packing-paper, the process becomes entirely unnecessary.

4. The Indian corn-paper possesses greater strength and tenacity than rag-paper, without the drawback of brittleness, so conspicuous in the common straw products.

5. No machinery being required in the manufacture of this paper for the purpose ef tearing up the raw material and reducing it to pulp, the expense, both in point of power and time, is far less than is necessary for the production of rag-paper.

Count Lippe having put himself in communication with the Austrian Government, an imperial manufactory for Indian corn-paper (*mais-halm papier*, as the inventor calls it) is now at work at Pesth, the capital of the greatest Indian corn growing country in Europe. Another manufactory is already in full operation in Switzerland, and preparations are being made on the coast of the Mediterranean for the production and exportation, on a large scale, of the pulp of this new material.

It is not merely the blades of Indian corn, but the leaves,

the tassel, the sheathing of the grain, the cob, and the stalk, might all, I believe, be utilized by the paper-manufacturer.

The German paper-manufacturers have been very successful in the production of paper and cloth from corn-husks, the machinery required for the manipulating process being the same as that employed in mills working on rags. The husks, it appears, are first boiled with an alkali in tubular boilers, as a result of which the fibres are found at the bottom of the boiler in a spongy condition, filled with a glutinous substance or dough, which latter is pressed out from the fibres by hydraulic presses, leaving the fibres in the shape of longitudinal threads, interspersed with a dense mass of short fibre. Linen that is made from these long fibres is said to furnish a very good substitute for the coarser kinds of flax and hemp, while it is superior to jute fabrics, Guernsey cloths, and the like. The paper—for which the short fibre is chiefly used: the long fibres constituting the material for spinning—is stronger than paper of the same weight made from linen or cotton rags. The hardness and firmness of grain characterizing the paper thus made are said to exceed that of the best-made English papers. Its durability is greater than that of paper made of most other substances, and it can be made extremely transparent without sacrificing any portion of its strength. The fibre is easily worked, either alone or mixed with rags, into the finest writing or printing papers, and it readily takes any tint or colour that may be desired. The yield of the husks employed for this purpose is said to be 30 per cent. of fibre, 10 of gluten, and 60 of dough.

It has resulted from experiments that a fibre could be extracted from the plant in a form like flax, by a very simple process requiring but little apparatus and auxiliary means; that it could be spun like flax and woven like flax-thread. The adaptability (if proved) of maize-fibre for spinning and weaving is of the greatest consequence in a commercial point of view, for the cultivation of this plant constitutes one of the most profitable branches of agriculture known, especially in America and parts of Europe. Without taking the corn into consideration, which already pays for its cultivation, the various parts of the plant can be utilised in many ways.

A very interesting collection of the products obtained from the leaves of the maize plant was shown by Austrian exhibitors at the London Exhibition in 1862. They included a nutritive breadstuff, a fibrous material, to be spun or woven like flax, and a pulp from which an excellent paper can be made; indeed, the Austrian special Catalogue for that Exhibition was printed on paper made from maize. The process, as carried on in the Imperial Paper Manufactory at Schlögelmühle, Lower Austria, gives a product of 100 lbs. of paper from 350 to 400 of the sheathing or head-leaves of the cob, irrespective of the subsidiary products. According to official accounts, the maize planted in Austria yields annually head-leaves estimated at 2,750,000 cwt., which, worked up into paper, would produce 1,500,000 cwt. So strong and durable is maize-paper, that if ground short it can be used as an excellent substitute for glass, so great is its natural transparency and firmness.

Even the cobs are turned to some use. A farina has been prepared from them in Austria, and they are ground up or boiled for cattle food. They supply the place of corks for bottles, are used as fire-lighters and as a fuel for smoke-drying bacon.

Economising Paper.—In view of the inadequate supply of material for making good paper, why should not society submit to allow it to be proper and fashionable to send only one leaf or only half a sheet of note or letter paper, since in seven cases out of ten letters are written on one side only. "Paper-sparing Pope" set a very good example more than a century and a half ago in writing his poems, and even his letters to noblemen and gentlemen, on the blank half-sheets torn from the letters he had received; and, as may be seen by his MSS. in the British Museum, contrived to utilise the blank sides of the wrappers or envelopes of such letters. I may cite even my own practice. Few perhaps have written more extensively for the press than myself. I invariably lay aside in a drawer the blank half-sheets of notes, news-wrappers, or any clean sides of paper at all available, and the bulk of my copy for magazine articles, leaders, and books, has during the past quarter of a century been thus written on stray slips, as the compositors in various printing establishments can

doubtless bear witness to. Would we had more paper-sparers among us.

The waste paper, twine, old quills, &c., of the Government offices in London, sold under contract, realize 10,000*l.* a year.

According to the Frankfort 'Zeitung,' a discovery has been made by Herr Kircher, of Wurtemburg, of a new means of using old printing ink. The essential part of the discovery is that, by a peculiar process, the ink can be completely removed from the surface of the paper, at a cost of two shillings for every hundred pounds of printed paper, and further, the material is then ready for use again.

Waste Paper for Household Uses.—After a stove has been blackened, it can be kept looking very well for a long time by rubbing it with paper every morning. Rubbing with paper is a much nicer way of keeping the outside of a teakettle, coffee-pot, and teapot bright and clean, than the old way of washing them in suds. Rubbing with dry paper is also the best way of polishing knives and tinware after scouring. This saves wetting the knife-handles. If a little flour be held on the paper in rubbing tinware and spoons, they shine like new silver. For polishing windows, mirrors, and lamp-chimneys, paper can be used in preference to any dry cloth. Preserves and pickles keep much better if brown paper, instead of cloth, is tied over the jar. Canned fruit is not so apt to mould if a piece of writing-paper, cut to fit the can, is laid directly on the top of the fruit. Paper is excellent to put under a carpet to prevent the ridges of the boards from cutting it. A fair carpet can be made for a room not in constant use by pasting several thicknesses of newspaper on the floor, over them a coat of wall-paper, and giving it a coat of varnish. In cold weather paper can be placed between the bed-quilts; two thicknesses of paper are as warm as a quilt. If it is necessary to step on a chair, always lay a paper on it: this saves rubbing the varnish. Paper-clippings are used for making pasteboard, and the most elastic ones are kept for stuffing pillows.

Tailors have been for centuries in the practice of stiffening and lining coats and vests with paper wrappers, but they have never dared to exhibit their false buckram. Not so now. The expert eyes of a Regent Street linen-draper

would not be able to detect the close imitation of the most improved Eglinton and Prince of Wales' collar, made of paper. The most critical eye in matters of dress will not be able to pronounce on the genuineness of many of these elegantly-made collars. The success of the paper-collars in London has induced many ingenious devices on other articles of dress. Perhaps the most extraordinary of these is a paper Dundreary necktie, which may be had for 2*d*., and with imitation gold pin 4*d*. Standing at the length of a yard-stick from a person wearing one of these paper neckties, the Tittlebat Titmouse of a London drapery would price it at the orthodox rate of 3*s*. 6*d*. The paper from which these ties are made is manufactured to imitate the leading patterns of cloth, and you have the quiet pattern of the sedate secretary of a Protestant institute, or the loud pattern of the fancy man of a London casino. Shirt-fronts and vests are now also made of paper. In the innovation that has taken place in this department, there are a few questions of considerable importance to the future race of washerwomen and soap-manufacturers. There is a story told of the grief caused by one of these paper-collars to the washerwoman of a hotel lately. A wag put a soiled paper-collar among his linen-collars that were going to the wash. The energy of the washerwoman was curiously misplaced on the collar, for the more she rubbed the less there was remaining to rub. The soap was supposed to contain some powerful acid, whose influence was such that it consumed the collar; for never before did she come across a collar made of paper, and with grief and contrition did she bring home the remnant of a once elegant Prince of Wales' collar.

Among the articles of every-day use which consume waste materials may be mentioned the universally-used paper-bag. The introduction of machine-made paper-bags dates subsequent to the Exhibition of 1851, and already all branches of trade—grocers, fruiterers, drapers, shoe-makers, ironmongers, druggists, are using them. The manufacture of this article is taking up a large share of the paper-makers' attention. The great consumption of grey and brown paper is falling into the hands of the manufacturers of machine-made paper-bags. One of the large London works employed in making them turns out 130,000

bags per day. The machine, which is of French invention, will turn out twenty small (in trade language 7-lb. bags), and twelve large (from 12-lb. to 28-lb. bags) per minute.

In the factories where albumenised photographic paper is made, a considerable quantity of paper is spoiled in the process, and it is then of but very little use. In Paris and Berlin this paper has always been washed as free as possible from the albumen, and then worked up into envelopes. Dr. Jacobson has found a new use for this paper. He proposes to stain it with aniline colours, and to employ it for labels, covers of boxes, and general decorative purposes. By being splashed with concentrated alcoholic solutions of the various aniline colours, the waste of these albumenised papers is now converted into marbled-paper of a much more beautiful appearance than what is produced by the old process, from the green-gold lustre which the films of those substances possess. The papers obtained by this method retain the gloss, the bright "satin" surface of the albumenised material, and are almost as brilliant by transmitted as by reflected light. They are said to be well adapted for shades, transparencies, paper-lamps, and other means of decorative illumination.

The Economic Uses of Peat.—The high price of coal recently has given an increasing interest to all that relates to peat as a fuel, and the subject which has been long studied by the scientific and industrial world, without much general result, is again coming prominently into notice.

The raw materials of some of the most important manufactures of the United Kingdom were not known before the present century to possess those properties which chemical science has since discovered in them, and which the manufacturer is now enabled to apply so largely to his own profit and to the use of the public. Among the most abundant of such materials, peat was, until lately, considered a mere fuel, rendering the districts occupied by it unfit for agricultural purposes, except at a cost wholly excluding profit; into its *chemical* properties and its commercial capabilities, no one thought of inquiring; of late, much more attention has, however, been given to the subject.

Nature has provided ample resources for the necessities

of the human race; to develop these resources is the province of man. It must be evident, however, to all intelligent people, that the more numerous our race becomes the more will man be beholden to science for the adequate development of these resources. What extensive tracts of peat we find scattered widely over the world!—in many parts useless—nay, in some cases worse than useless, spreading ague and fever far and wide. The use of peat as fuel is already extensive; in many parts of the continent of Europe it is almost the only fuel used. Hundreds of people find employment in transporting it on the Elbe to Hamburg, and other markets on that river. In Jutland, in Denmark, extensive bogs exist, many of which afford excellent fuel both for domestic purposes and for burning lime, bricks, &c. Some kinds make very hot fires: I have seen in a limekiln in Denmark, where peat was used, vitreous slags produced that indicated a high degree of heat; there is also a kind in the neighbourhood of the small town of Grenaa, called Ramten-turf (from the place where it is obtained) that produces good charcoal which is used by smiths.

In European countries, and more recently in Canada and the United States, peat has commanded much attention as a cheap and convenient fuel. In its natural state, or merely air-dried, it has been much employed for local consumption, though of very inferior heating power to coal; but when pulped and compressed and thoroughly dried, it has been found capable of competing with coal and wood on equal terms, both for steam production and domestic use. Charred peat has also become an important article of consumption as a substitute for wood charcoal and coke.

A company has been formed in Italy for working some of the numerous peat deposits in that country. A machine recently patented by Signor Moro is to be used for compressing the peat, and is stated to have given excellent results at some trials recently made at Florence. The fuel manufactured on this system has been used extensively by the Alta Italia Railway Company, and, as compared with English coal, a saving of 40 per cent. in expense is effected. The high price of coal in England will doubtless offer an opportunity to utilise the abundant

deposits, not only of fuel, but lignite, and other fossil fuel, which are met with in many places in Italy.

Both in Sweden and the United Kingdom immense and apparently inexhaustible deposits of peat exist, which by Eichorn's patent process can be converted into hard and dense balls of fuel, of irregular size, requiring no breaking, almost smokeless, and very clean, leaving but little ash, and generating steam quicker than coal, without fouling the flues or injuring the bars and boilers. It is therefore admirably adapted for both household and manufacturing purposes, and also yields large quantities of superior gas.

This fuel has been tried by one of our largest railway companies, and by one of the river steam-boats, as well as for smelting, with most satisfactory results.

To establish the fact that peat can compete successfully with other fuels, it is only necessary to examine the following table, which gives the calorific power of one kilogramme (2⅕lbs.) in different states of dryness.

Wood dried at 100°, 3600, and with 25 per cent. of water 2750.

	Dry state.	With 10 per cent. Water.
Anthracite	8000	7150
Pure carbon	7800	7000
Wood charcoal	7300	6500
Coke of moulded peat	7400	6500
Coal, 1st quality	6000	5350
Coal, 2nd quality	5500	4850
Coal coke	6500	5800
Peat coke, ordinary	5500	4900
Peat, purified and pressed	4500	3900
Ordinary peat	3200	2800

From these figures it is evident that peat merits the serious attention of metallurgists and economists, but as yet it has not been sufficiently studied.

The advantages resulting from the use of peat fuel are such as have induced many foreign manufacturers to use it in some branches of the iron manufacture. From the researches of a commission of French engineers, who, a few years ago, by order of the French Government, published a report of their labours, I gather the following interesting information :—

It appears that in the department of the Landes, France, there are iron-works at Ichoux, which consume peat or turf only; the cost there is about 8*s*. per ton. Forty-

five per cent. of turf and 23 cwt. of pig-iron give 1 ton puddled iron. Twenty-six cubic feet of turf and 25 cwt. pig, yield 20 cwt. of bar-iron of superior quality.

M. Muller, of Wadenhammer, a leading manufacturer, has proved, by actual working test, that an equal quantity of peat-charcoal, used in place of wood-charcoal, produces a greater quantity of produce from the ore than the best wood-charcoal.

At Wachter Newnhammer, it was found that when equal parts of turf-charcoal and wood-charcoal were used in place of wood-charcoal, alone, the quantity of iron was raised from 386 lbs. to 464 lbs., the quality being excellent.

There are at Ransko, in Bohemia, iron works for smelting, cupelos for re-melting pig, and reverberating furnaces, &c., for making bar and plate iron. The ore is but middling in quality. The fuel used is turf and charcoal only, the turf being of light texture, and not in any way prepared or pressed. The fuel consumed to make 1 ton of iron is about 34 cwts. of turf and 30 cwts. of charcoal; the cost of the first is less than 9*s.*, the latter about 1*l.* 4*s.*; smelting, therefore, costs about 1*l.* 13*s.*, and the total cost of pig-iron about 3*l.* 15*s.* per ton. The quality of the iron is the highest.

In Bavaria there are iron-works similarly worked. One at Königsbrunn carries on the whole operations of fusion, puddling, re-heating and rolling, solely by peat fuel. The commissioners state that the turf is not pressed, but carefully dried by means of heat from separate fires or from the furnaces. Bertheir states the analysis of this turf to be:—

Volatile matter	70·6
Carbon..	24·4
Ashes	5·0

30¼ cwts. of this turf to 22½ cwts. of pig produces 1 ton puddled iron.

30 cwts. of dense turf to 24½ cwts. of puddled iron produces 1 ton small bars of fine quality.

The apparent average is, that 32 cwts. of properly dried turf to 20½ cwts. pig, gives 1 ton castings; 30 cwts. turf to 21 cwts. flat iron, 1 ton plates.

By compressing peat its value as a fuel for metallurgic

operations is much increased; and when compressed peat is carbonised, it gives a fine coherent coke, which contains very little ash. When the coking is properly carried on the peat yields about 30 per cent. of its weight of coke, and the density of this coke is greater than that of wood-charcoal, being found to range from 913 to 1040. The iron furnaces of Voitumra give a still higher percentage of coke when the peat is coked in small vessels.

The precise figures are:—

Charcoal	40·25
Tar	24·50
Watery liquor	14·00
Gaseous matter	21·25
	100·00

The calorific effect of peat-charcoal uncompressed is about the same as coal-coke, while that of compressed peat-charcoal is, as before-mentioned, much greater. The value of peat-charcoal, whether made from compressed or uncompressed peat, is evident, as is also the increased value of iron made by means of such fuel. I take these to be incontestable facts; and it is almost incredible that so valuable an article as peat should have remained so long almost unnoticed and unemployed by our metal manufacturers. The neglect of peat as a fuel may, and probably has, arisen partly from its bulky nature, and partly from the open or spongy character of a great deal of the peat that is dried in the open air in the natural way, and which renders it inapplicable, or, at any rate, inconvenient, to be used as a fuel for smelting purposes. The compression or solidification of peat by ordinary mechanical pressure, is an expensive and slow process when applied to large quantities; and, therefore, even although such an operation could be made effectual in pressing the water from the peat, the extensive and costly plant that would be required to work on a scale sufficiently large to meet a moderate demand, would act, and no doubt has acted, as a barrier to extensive operations being carried on for this purpose.

The use of peat-charcoal in high furnaces is not quite satisfactory on account of the quantity of cinders it leaves, and the low pressure it will support. At Undervillers,

Jura, Switzerland, peat is employed as a fuel in the iron furnaces, and the iron made with it has advantages over that made with coal, that it is softer, does not oxide. In Italy peat is employed for the furnaces on Siemen's system.

For heating locomotives it has been found in France that it requires 30 per cent. more of turf than of the best coal-coke, but the coke of the second quality is not superior to peat. Well prepared peat or turf presents the following advantages for steam-boats and locomotives:—

1. It affords greater facility for stowage than wood.

2. It does not give out sparks from the chimney, which frequently causes fires in the course of the railway.

3. It gives out more flame and lights easily, which facilitates high pressure when required.

4. It produces a more regular and steady heat, and permits a more easy management of the fire, for the turf does not form scoria on the bars, and intercept the passage of the air necessary for combustion.

From a Report presented by Messrs. Laroche and Co., of Saulun, Vosges, on the heating of the locomotives of the Eastern Railway of France in 1866, it appears that it takes about 1500 kilogrammes of peat to 1000 kilogrammes of coal, to obtain the same results, which is a great economy, since the ton of coal costs them 36 francs, and a ton and a half of peat 18 to 20 francs, or about one-half. The peat used was one of the best kinds, obtained from the mountains and well prepared. M. Laroche, director of the "Société des Tourbières" of Vosges, having studied for many years the best processes employed in France and abroad for prepáring peat, has obtained a very superior quality of products, specimens of which were shown at the Paris Exhibition in 1867.

Mr. Newnham, the British Consul at Amsterdam, thus reports on the production and use of Turf as Fuel in the Netherlands:—

Peat or turf, now generally considered to be a vegetable matter, formed by the decomposition of plants amidst an abundance of moisture, and varying in colour from light brown to blue-black, according to its more or less perfect state of decomposition and the depth of the layers, is extensively used for fuel throughout the Netherlands.

With the exception of a moderate supply of wood, it is, in fact, the only kind of fuel the country produces, so that even in remote times the attention of the industrious inhabitants was directed to the expediency of cutting up and clearing the immense tracts of peat-bog or waste land in the northern provinces, particularly in Friesland, Groningen, and Drenthe, with the two-fold object of applying the combustible matter on the surface, to a depth of from two to twenty-five feet, for fuel, and of bringing the soil below it into a state of cultivation.

Peat, however, being a light and bulky kind of fuel, is not adapted for exportation, as it cannot be conveyed to considerable distances without too great an expense, so that its consumption is confined to the country where it is produced. This is the principal reason why the reclaiming of vast waste lands in many districts is not carried out on a more extensive scale, for if too large a quantity of peat were to be produced at one time, the market value would be reduced to such a low figure that the proprietor or contractor, instead of making a profit, would have to sustain a considerable loss. It is true that the soil below is usually found to be well adapted for conversion into arable land, but it takes a number of years, and requires a considerable outlay in wages, to arrive at this desideratum.

As yet peat has been chiefly employed for domestic purposes, in the manufacture of bread, bricks, tiles, &c., and, in general, wherever the use of a more compact kind of fuel is not a requisite. But of late years efforts have been made to render it more generally useful by compressing it until its specific gravity is nearly equal to that of coal. The well-known peculiarity in the character of the Dutch people in general, viz., that of strongly adhering to old habits and customs has, however, hitherto proved a stumbling block to the manufacture of this new article, so that the compressing of peat has not been prosecuted on an extensive scale, notwithstanding that its advantages in every point of view are sufficiently obvious.

The ordinary way of reclaiming the high peat-bogs in this country, and of preparing the layers of peat for fuel, is as follows:—After having ascertained, by borings, that the portion of bog intended to be operated upon is likely to prove sufficiently remunerative, the first essential is

drainage. The method of effecting this varies according to circumstances, but the system generally adopted in the high moors of the northern provinces of this country, after that a general outlet with sufficient fall has been secured, is to divide the tract into strips, by cutting open drains of about 39 inches wide by 33 deep through the whole length. These strips, usually about 136 yards in breadth, are then traversed or subdivided by smaller drains. Having thus prepared means for drawing off the water and partially drying the peat, nothing further can be done for a considerable time, varying from two to ten years, except occasionally deepening the drains a few inches whenever the marshy state of the soil permits it. As soon as the bog has sufficiently settled down and is fit to be operated upon, the crust or surface is pared off with the spade to a depth of from two to four feet so as to remove the coarse, undecomposed, vegetable matter, which, though unfit for fuel, is yet carefully put by for future use in bringing the under soil into a state of cultivation. The peat is then cut out in pieces like bricks, by means of a long, narrow spade, and conveyed to an adjoining strip of ground, which has previously been covered with a thick layer of the above-mentioned parings, where they are set up in rows to dry. The process of drying being invariably done in the open air, it depends entirely on the state of the weather; and it not unfrequently happens, after a wet summer, that consumers who have not laid up a stock of turf dried in the previous year, are obliged to make use of the new stock in a damp state.

This is the simplest and most usual method of saving and drying turf. The new plan, however, of compressing the peat and considerably reducing its bulk, offers many advantages, as for instance:—

1st. It is at once remunerative; for by this system the whole depth of combustible vegetable matter, whether partially or entirely decomposed, is reduced to a pulp and mixed together, consequently one part thereof is not more valuable than the other; whereas, when turf is procured in the ordinary way by cutting out layer after layer, the upper part, being less perfectly decomposed and therefore of an inferior quality, has to be disposed of at a price that does not even pay the cost of labour, so that the propriotor

or contractor does not obtain any profit or interest for his outlay until two or three years later, when the lower and more valuable layers are brought to market.

2nd. Compressed peat is an excellent substitute for, and with regard to cleanliness, a much superior article than coal. Being far more compact than ordinary turf, it can be conveyed and warehoused at a considerably cheaper rate, so that when once its advantages are fully appreciated, it cannot fail to come into use for many purposes for which ordinary turf, through its bulk, is totally unfit.

And 3rd. As the process of drying does not depend on the weather, compressed peat can be produced with far more certainty and expedition than ordinary turf.

A few years ago an attempt was made in this country to introduce peat-charcoal or carbonized turf made from compressed peat, but although it was proved by chemical research that this article was equal, and, in some respects, superior to wood-charcoal, the consumption was so small that the enterprising manufacturer was compelled to abandon his scheme, because it would not pay as a commercial speculation, unless considerable quantities were consumed.

Compressed peat or turf is formed by machinery. The raw material having been dug out of the beds, has to be ground, mixed, compressed, and formed into blocks. The object of grinding or cutting up the raw material is to destroy the roots and fibres of plants contained therein, as these absorb a great quantity of moisture, and are the cause of much delay in drying ordinary turf.

From the information I have been able to procure on the subject, it would appear that the transportable turf presses, both horizontal and perpendicular, manufactured by Messrs. Schlüter and Maybaum, of Berlin, are superior to any other that have as yet been introduced. These presses, which are supplied of various sizes, sometimes a pair coupled together, are driven by donkey-engines of from six to twelve horse power, and combine the process of grinding, mixing, compressing, and forming the raw material into blocks. The price varies from 100*l.* to 350*l.*, according to size, with the largest from 50,000 to 60,000 blocks or turves, of about 12 inches in length by 3½ inches breadth and depth, can be manufactured in a day of 12

hours, with the assistance of 8 men and 4 boys. The weight of such a press would be about 7 tons.

A description of Messrs. Schlüter and Maybaum's presses, by Dr. Robert Schmidt, of Berlin, is to be found in 'Dingler's Polytechnic Journal,' 1867.

All that I have already stated refers to the extracting of peat from the high beds, that is, those the bottom of which, after removing the peat, is still more or less above the level of the water.

It now only remains for me to describe the mode of extracting peat from the low beds, or those situated below the ordinary water level, but covered with a crust of clayey soil, forming, in most cases, excellent arable land and annually yielding abundant crops. In olden times only barren land was used for this purpose, but at a later period proprietors of land, tempted by the profits produced by the peat trade, were induced to destroy fertile plains and fields for the purpose of extracting the peat hidden beneath the upper soil.

The result was that in many parts of the Netherlands rich fields were continually being converted into lakes, until the Government at last interfered and set a limit to these proceedings.

At the present time no one is allowed to extract peat from land until he has obtained permission from the authorities, and this permission is not granted unless the parties interested bind themselves to excavate the turf and drain the bottom of the peat-bed within a fixed term.

The system generally adopted is as follows:—During the winter the upper crust, usually about two or three feet deep, is carefully removed and deposited in another part of the field, until the peat has been extracted and the water drained off, when, as with the high peat-beds, it will form the basis of fresh cultivation. As soon as the upper surface is removed, water appears, and the bed of peat underneath is left bare until the following spring, when workmen in long waterproof boots get into the water with spades and extract the peat.

As the surface of the water completely conceals the peat-bed, these men do not see what they are doing, but feel their way and cut the earth with their spades, seize the divided sod, and throw it into a barge. The barge

having been filled is brought to land and the peat discharged into a wooden trough, where the shapeless and compact sods are crushed by a workman with his feet, and simultaneously freed from large roots, stones, and other impurities.

After the peat has been kneaded like dough in the wooden trough, it is thrown on the ground and left for a short time to dry. When sufficiently dry it is trodden down by other workmen, with little planks fastened to their feet, and soon presents a smooth surface. After this process the peat is again left to dry, and then divided into oblong squares by means of a kind of rake. After a time the divided pieces are taken up with spades and placed in rows and heaps until completely dry, which usually takes about three months, and then brought to market.

When the low peat-bed is worked out nothing remains but water, which, after having been surrounded by an embankment, is pumped out by wind-mills, and the ground underneath, with the help of the upper crust of the peat-bed which was previously removed, converted into arable land.

In conclusion, I may observe that I have learnt from Irish landed proprietors that the peat or turf of their country is far inferior to that of the Netherlands."

Mr. Fontein, British Vice-Consul at Harlingen also writes on turf-fuel in Holland as follows:—

"The manufacture of turf is generally desirable for two reasons, first, because of its importance as fuel in a country devoid of coal, and secondly, because thereby the higher peat levels are removed, and the lower soil is ready for cultivation.

The greatest portion of our high-level peat is dug for fuel. The quality of course varies. This is influenced in the first place by the thickness of the layer or stratum, and also by the position in regard to drainage. All turf, however, is used for fuel. The lowest quality is taken by small manufacturers (such as mortar, brick, and tile works); the better qualities are used for domestic purposes.

The production of turf is generally carried on as follows. After the necessary preliminary work has been effected, which consists in draining the peat sufficiently to procure a proper consistency, the turf is dug; after which it is

stacked in squares and dried in the air, when it is ready for sale. This is the simplest and most generally adopted course of procedure.

During the last few years operations have been carried on in several places for the purpose of preparing turf by artificial pressure, and some experiments have also been made by which a kind of carbonised turf (coal-turf) has been produced.

The compressed turf quite answers to its purpose, although owing to the well-known slow manner in which all old habits and customs are given up in this country, the favour it has found has not been sufficient to induce a great extension to these works.

Compressed turf has, however, many advantages.

1. A very uniform value is established for all descriptions of peat. In the usual methods of working turf, the upper crust has to be sold for what is usually less than the expenses of working, and consequently profits only come in after the upper strata have been removed.

By the system of compressed turf all the descriptions of peat which can be dug with the spade are mixed.

2. The transport and use are much facilitated. It is clear that the compactly-pressed turf takes up much less room, which is, of course, a saving in its transmission and warehouse rent. The increased facility in its use is owing to the larger quantity of combustible matter in a smaller surface.

3. The preparation is more certain and more rapid than by the old system of digging, where the turf is dried by the influence of air and sun. In wet weather this is scarcely possible; and the consequence is, that imperfectly dried turf is thus brought to market.

By steam pressure the moisture in the peat is almost entirely expressed, and one can therefore reckon with certainty upon the article being shortly in a fit state for use.

The smaller compass requiring so much less space for final drying, quicker delivery, and consequently increased trade, are so many self-evident advantages requiring no comment.

The system of manufacturing turf by artificial pressure which is adopted is as follows:—

The peat is thrown into an open tank and pressed by

steam power (8 to 10 horse power), the water being allowed to escape; after which the turf is cut into equal sizes by a very simple machine.

I do not know what is the cost of the machinery. If I am not mistaken, such a machine is capable, with the assistance of 8 or 10 men, of turning out 40,000 turfs per diem, sufficient to realise a nett profit of 100 fr. (8*l.* 7*s.*)

Carbonised turf I do not think is made in this country any longer. The increased expenses, as compared with the small return, offered no temptation. But it has been proved by scientific examination that it was capable of being used as a substitute for charcoal of the best description. The heating power was, as compared to the best beech charcoal, as 85 to 100.

Development of high-level turf for fuel where no coal exists is highly desirable. Not only do we thereby obtain a good, and in proportion to coal, a cheap description of fuel, but opportunities are created for the cultivation of the subsoil, which would otherwise remain wholly unproductive, of which a striking example is exhibited by the peat colonies of the northern provinces of the Netherlands, which in the course of years have changed from bare wildernesses to rich agricultural districts, not inferior or less productive than the original river lands."

Russia is rich in peat bogs, and the rigour of the climate necessitates a large consumption of wood. In order to popularise the use of peat, it is highly necessary to study and extend the best modes of preparation, and whenever a good peat can be furnished at a price much below that of other fuels, it will become very generally adopted.

Ireland possesses in its peat a great source of wealth and profitable employment, and all that is wanted are capital and science to make the possession available to the public use. The whole extent of bog was estimated a few years ago at 2,800,000 acres; nearly one-seventh of the entire surface of the island. Some portion of this, however, has lately been reclaimed. With this immense magazine of wealth at command, it is not too much to assume that the peat tracts may become to Ireland what the coal mines are to England, or steam-power to the English, Scotch, and Welch manufacturers—sources of industry, wealth, and public enterprise. Meaux in France, and Tours, are now

lighted with gas made from peat, and a society has been formed there for the production of gas from peat.

In May, 1860, Mr. W. E. Newton read a paper before the Society of Arts, London, "On the Employment of Peat in the Useful Arts, together with an account of some recent improvements in the preparation of it for various useful purposes," from which I quoted largely in the first edition of this work.

Peat burns best in chimneys that have a powerful current, which will carry off the smoke and smell in the same manner as they do those of coal. But it is in the several arts and manufactures that peat is more peculiarly useful. In France it is employed in furnaces under boilers, in burning brick and lime, and in preparing plaster. The ashes are very valuable in agriculture, and command a high price. Peat admits of being charred, when it loses its unpleasant odour, and may then be used as a substitute for the various kinds of coal in all the arts.

Ordinary air-dried peat, even if of the best quality, can neither be employed in blast furnaces nor in reverberatory furnaces, owing to the fact that it still contains from ten to twelve per cent. of water. As soon, however, as this amount of water is driven off by well drying the material, it produces an exceedingly strong heat, which is available for the smelting and puddling of pig-iron, and in proper furnaces even for the welding of wrought iron. The drying of the peat is accomplished in proper drying ovens, in which from 3000 to 5000 lumps can be placed; the time necessary is from ten to fourteen hours, and the temperature from 100° to 120° Fahr. For the production of heat, the waste heat of other furnaces, or that from special fireplaces, is used. From ten to fifteen parts of peat, according to the degree of moisture, can be dried by means of the combustion of one part.

Since for steam-boilers dry peat is not always on hand, the quantity to be used the following day should be placed upon the walling, and during the night the place ought to be well closed, so that the material may have a chance to dry.

Peat is commonly dug in lumps of 10 by 4 by 3 inches, which are very well adapted for fuel; many lumps break into smaller pieces, but this is of no disadvantage. Of late, peat is frequently compressed into the more compact and solid form of peat-bricks, in accordance with the commendable method of Exter. These are especially well-fitted for

the firing of steam boilers, provided they can be had on reasonable terms. These bricks, crushed into smaller pieces, prove very good generators of steam; they are successfully used in Holland and in Bavaria for this purpose.

When peat is submitted to a high temperature, continually increasing, the water it contains is utilized as well as the carburetted hydrogen and gas. These are decomposed and yield different products which have not been sufficiently studied, hence they have not attained the importance they merit. By proper and skilful management many of these might become valuable. These products and bye-products are tar, heavy and light oils, essential and volatile oils, ammoniacal liquors of great strength, gas, oxide of carbon, &c. The solid residue obtained by this volatisation is a charcoal intermediate between that of coal and wood, its calorific power being very high, varying between 4850 and 6800, according to the quality of the peat and the greater or less quantity of ash and water which the peat coke contains.

The carbonisation of peat is of very ancient origin.

Without entering into details as to all the different systems of carbonisation, it may be interesting to give the composition of a ton (1000 kilos) of moulded peat from the marshes of Montane, France, the proportions being 50 of tar, 340 of ammoniacal liquor, 405 of charcoal, and 205 of gas and loss, which were made up as follows in kilogrammes:—

Light oils, 20, viz.,	Benzine	3
	Illuminating oil	5
	Greasy oil	8
	Neutral basic oil	4
Paraffine oils, 15,	Phenic acid or creosote	5
	Paraffin	3
	Carbon and graphite	2
	Gas, residue and loss	5
	Ammoniacal liquor	4
	Dry pitch	9
	Loss	2
Ammoniacal water,	yielding 22 kilogrammes of sulphate of Ammonia	340
	Charcoal	260
	Small	110
	Dust	35
	Gas and loss	205
		1000

The manufacture of lampblack from peat, and its products of distillation is comparatively new, and this lampblack is far superior to that made from coal, coal tar oil, asphaltum, and all such matters. The peat tar obtained by the distillation of the ordinary peat, or of the condensed or solidified peat, may by repeated distillation and certain other processes be transformed into a variety of sub-products, such as photogen, paraffin, naphtha, and others; instead, however, of forming any of these products, this invention has for its object the manufacture or production from peat, from the oils obtained from peat, from peat tar, and peat asphaltum, of the substance known as lampblack, and the crude oil obtained by the simple distillation of peat tar is used in preference for this purpose.

This lampblack may be produced in a vaulted chamber, along the side or sides of which pipes are placed, which pipes can be supplied with the crude oil from without the vaulted chamber. The pipes are fitted with a number of small holes or tubes, into which wicks are inserted, and which form in this manner a system of lamps. The admission of air is so regulated by means of dampers, valves, or gratings, fitted into the walls of the chamber, as to produce an imperfect combustion, and at the same time the largest possible amouut of soot. For producing lampblack from asphaltum obtained from peat tar, a vaulted chamber similar to the one described may be used, the pipes forming the system of lamps being omitted. This vaulted chamber is connected with a flue, into which flue, when heated to a red heat, the asphaltum is thrown in lumps. The asphaltum will suddenly ignite, and, owing to the limited admission of air, produce large quantities of soot or lampblack, while the heat from the combustion is sufficient for keeping up the temperature of the flue. The lampblack thus produced is, however, inferior to that made from peat tar oil. The process of manufacturing the peat lampblack does not differ widely from some of the processes used in treating coal tar, asphaltum, &c., but the invention is interesting, as affording another means of using peat.

The mail steamer which plies between Stornoway and Ullapool has her engines fed entirely with peat, and the experiment seems successful in every way. The peat

here is very exceptionally fine, and it was this quality which, thirteen years since, suggested the idea of testing its value as a means for the production of paraffin oil. In 1859 the natural oil springs of America were unknown. Hydro-carbon oils were obtained only from boghead coal, shale, or Rangoon tar, and commanded considerable prices. In 1857 some experiments were made with the Lewis peat, and the crude products submitted for examination to some eminent chemists, whose report was so far favourable that two years later Sir James Matheson erected the works which are now in active operation. They stand by the side of the river Creed, about two miles from Stornoway, and in the very heart of the district where the material necessary to supply them is most rapidly and to the greatest depth developed. The method by which the crude oil is obtained is that technically known as "destructive distillation." A series of ten egg-shaped furnaces, built of brick, ranged five on either side of a tramway erected for the purpose of conveying the peats from the ground to the fires, stand immediately at the threshold of the factory. Fire baths are placed beneath each of the furnaces for the reception of solid blocks of the raw material. Above these bars are doors for the withdrawal of the red-hot charcoal. Each furnace is capable of containing about two tons of peat when fully charged. Outlet pipes, connected with a large iron main, conduct the melted peat to a series of condensers. A steam-engine is attached, which drives an exhaust fan.

The fan being set in motion, a partial vacuum is formed in the condensing pipes, the main and outlet pipes—the air rushing up through the fire bars, and the furnaces filled with peat to supply the place of the exhausted air. Fire is then set under the peats in the different kilns, and the draught created by the suction of the fan soon causes the peats to ignite. As soon as the fire has got to a certain height in the kiln the supply of air is diminished, so as to prevent too rapid exhaustion. In a short time the heat given off by the ignited fuel at the bottom is sufficient to cause a distillation of the oily or tarry matter from the superincumbent peat. As the distilled matter passes through the condensing apparatus, the tarry or oily part mixed with ammoniacal water is condensed, and only the

gases escape, of which the chief is carbonic oxide. When the kilns are fairly alight, and all atmospheric air is expelled, this carbonic oxide is used in the place of fuel, raising the steam for the engine; burning about 20 barrels of shells into lime daily, concentrating the ammoniacal water for making sulphate of ammonia, and evaporating large quantities of water which, if let run into the river, would destroy the fish. The tarry matter comes off as a thick, brownish, creamy-looking substance, and is conveyed into a large receiving tank, where the tar and water are to be separated. At the bottom of this tank is placed a strong well-riveted iron box, about seven feet in diameter and five inches deep. The heat of the exhausted steam discharging into the box, causes a perfect separation of the tar and water, the former immediately rising to the surface, and when cold solidifying into a black mass. The yield of the average of the peat is about seven and a half per cent.; that of the finest black peat ten per cent. The refined oils and the paraffin substance itself are obtained after a distillation of the tar, the distillate being treated in the usual way with acids and alkali. The late Dr. Penny, professor of chemistry at Glasgow University, reported on the Lewis paraffin oil most favourably, stating that its light-giving power was equal to any of the hydro-carbon oils, and that its highest igniting point, 190 degrees, perfectly astounded him.

The natural deficiencies of the island are supplemented in a curious and interesting way by these operations of human science. The charcoal taken from the furnaces is saturated with the ammoniacal water, crushed, and spread on the newly dug or trenched peat. Its effect is miraculous. In a very little time it superinduces a richly luxuriant growth of grasses, and the raw mass is as fruitful as the most highly prepared soil. The mode, above described, adopted in the Lewis work of distilling tar from peat is, I believe, unique, and it certainly possesses this advantage over the old retort system, that it involves no wear and tear of costly iron instruments; that the fuel which is required to heat them is saved; and that the brick-built furnaces are for all practical purposes as good as new after twelve years' work. The sale of the peat-manufactured paraffin of Lewis has been most prejudicially

affected by the inundation of the home market with American oils. Still, a considerable quantity continues to be manufactured, and a very valuable employment is thus afforded to a number of poor people. Assuming the works to be in full swing, the amount of peat required for a year's consumption is not less than five thousand tons. The mere manufacture of the oil alone requires the services of from thirty to forty men. The peat used is generally all cut in the months of May and June—cutting, drying, and stacking being performed by contract. All the peats when dry are stacked along the tramways in heaps about nine feet thick and eight feet high. Such are the Lewis peat works, a curious monument of advanced chemical science, in a remote region, where civilization itself is a novelty.

Waste Products of the Cocoanut.—There are few articles that have risen into greater importance, in an economic point of view, than the fruit of the cocoanut palm, and yet we only receive the quantity in excess of that required by the inhabitants of the country where it is produced for their daily support.

Many years ago the late Dr. Royle estimated the cocoanuts produced annually in Malabar at from 300,000,000 to 400,000,000. In Travancore there were more than 5,000,000 cocoanut palms, and, with the demand for oil and coir, the culture has largely increased. In Java and Madura there are more than 20,000,000 cocoanut palms, and it also abounds in the rest of the Eastern archipelago. In the West Indies and Central America the cocoanut is extensively grown. There are groves of this palm for about 280 miles along the coast of Brazil; and from the port of Para alone 7,500,000 cocoanuts are annually shipped to the United States. The tree is very widely spread over the Pacific Islands.

The economic products of the cocoanut are numerous. Besides the oil which we import, to the extent of about 200,000 cwt., fibre, yarns, rope, matting, brushes, and brooms, are made of the coir from the husk. The shells are largely used for hookahs or pipe-bowls; they are also mounted for drinking-cups, made into water-ladles and spoons, turned into beads, and other fancy articles are carved from them, and, when burnt, they make excellent charcoal for dentifrice.

Poonac, the refuse marc or cake of the kernel after the oil has been expressed, is used for fattening fowls and cattle, and makes an excellent manure. The dried pulp, under the name of copperah or copra, is largely imported into this country for making oil. Coir is much used in India to stuff mattresses, couches, saddles, &c., and for making brooms and brushes to whitewash houses.

There are imported into the United Kingdom 3,500,000 cocoanuts, and the husks are collected from the fruiterers and sold to be made into fibre for spinning. The husks of forty nuts will yield about 60 lbs. of coir.

In the West Indies, France, and other countries, where they wax and polish their wooden floors, the fibrous pericarp is employed as a rubber. By means of ingeniously constructed machinery the fibre of the husk is now rendered sufficiently fine for the loom, and matting of different textures with coloured figures is produced, while a combination of wool in pleasing designs gives to it the richness and effect of hearth-rugs and carpeting.

The application of cocoanut fibre as a substitute for horse-hair and bristles is even more important than its use in a woven state, though it met with little encouragement as long as the fibre was offered only in its raw state; but the aid of machinery and improved means of preparation have enabled the manufacturer to obtain the material in a much more serviceable form, and at a reduced price. The fibre is dyed black, and mixed with horse-hair; it is then curled and baked in an oven, and afterwards pulled apart by women; and, when properly prepared, it resembles horse-hair to such a degree that none but a practised eye can detect the difference.

Perhaps there are few commodities which have had to contend against so much opposition as the cocoanut fibre. A really good, useful, and cheap material, it still had for some years to contend against the interested opposition of what is called the "trade," or middle-men who come between the manufacturer and the public. Even now the cocoanut fibre is not so well known to the public as it should be, from its being so extensively used, we must not say for adulteration, as it improves while it cheapens, but for mixing with horse-hair. Owing to the recent advance in the price of raw hair, the use of cocoanut fibre has

increased to such an extent, that scarcely any curled hair of the best quality is brought into the market without having a large proportion of cocoanut fibre mixed with it.

The cocoanut fibre is durable, clean, and cheap. The jurors of the Great Exhibition of 1851 bore testimony to its merits for bedding in the following terms:—"The use of cocoanut fibre for bedding presents many advantages; it does not become knotty or hard, it does not harbour vermin, and it is not affected by variation of climate; it is also recommended by the great cheapness at which it can be produced."

In the last twenty years the manufacture of cocoanut fibre has been greatly developed. The strongest of the fibres of the cocoanut are now selected and extensively used by brush-makers as a substitute for bristles, for which purpose the material is admirably adapted. It is said that for some brushes, as, for instance, scrubbing and stable-brushes, the cocoanut fibre is preferable to the best bristles, not only on account of its cheapness, but as being, in reality, better calculated for the uses to which such brushes are applied.

Not to speak of the oil, the subsidiary products of the cocoanut have risen into immense importance in the last quarter of a century. From Ceylon, the chief seat of production of this palm, the exports of coir were under 20,000*l.* in value in 1851, and it was then chiefly used for making yarn and rope, now the United Kingdom alone imports from thence fibre and yarn, &c., to more than double that amount, and averaging about 50,000 cwt. Even the value of the shells of the nut exported from Ceylon amounts to about 500*l.* a year.

The cultivation of the cocoanut has largely increased in Ceylon, although the price of the oil in the London market has latterly been adversely affected by the increasing imports of palm-oil. So far back as 1857 the value of the products of the cocoanut shipped from Ceylon was 274,462*l.*, viz.:—

	Value.
Cocoa nuts, 1,420,856	3,717*l.*
Coir rope, 18,881 cwt.	13,984*l.*
Coir yarn, 31,652 cwt.	21,364*l.*
Copperah, or dried cocoanut pulp, 20,381 cwt.	12,143*l.*
Oil, 1,767,431 galls.	223,254*l.*

These were chiefly the produce of native plantations

situated on the south-west side of the island. There were about 22,000 acres of cocoanut trees under cultivation by Europeans, but none of them were then fully in bearing. In the ten years ending with 1869, the value of the shipments from Ceylon were: oil, 1,445,928*l.*; coir, 342,622*l.* The quantity of oil shipped does not vary much, being on the average one and a half million gallons yearly; but the coir has doubled in the last ten years, now amounting to 67,000 cwt., worth about 45,000*l.* for the mere husk of the cocoanut.

Coir.—The short, woody, and apparently intractable husky fibres lining the inside of the husk of the cocoanut constitute the material which Hindoo ingenuity has long since converted into excellent cordage. They are first soaked for some time in salt water until they become soft, then beaten to separate the woody substance connecting them, which falls away like sawdust, leaving only the strings. This refuse or dust left in the preparation of fibre in England is now an article of commercial importance and sold in bags as mould for plants in greenhouses and gardens, &c., at 2*s.* 6*d.* the sack or cwt. It is the best of all composts for ferns, acacias, azaleas, camellias, rhododendrons, &c., and a good dressing for lawns. Potatoes thrive in it. From a nine-yard row of each, those simply manured yielded 2 stone 8 lbs.; those grown in the cocoa fibre dust 3 stone 4 lbs. Mr. Bayham, of Kingston-on-Thames, took out a patent for making papier-mâché out of this refuse.

A patent was taken out by H. Reynell, of Exeter (No. 1423), 8th June, 1863, for using cocoanut fibre as a substitute for ordinary felt and kamptulicon, and in utilising parts of the husk for packing of wine-coolers, refrigerators, and ice-chests, and caulking of ships and vessels.

There is a similar Eastern fibrous product worth attention, which is not yet utilised, and that is the husk of the betel-nut (*Areca Catechu*), so largely used throughout India and the Eastern Archipelago. The nuts are very much smaller than the cocoanut. At Travancore the quantity grown is enormous; 4000 tons are annually shipped from Ceylon to different quarters; in Penang 3000 tons are produced, and in Sumatra 4000 to 5000 tons, besides large quantities in other quarters. They have to be husked, and the fibre is worthy of notice because of its capability of being turned

to many useful purposes, especially as it has a soft and cotton-like feel, and is capable of being spun into twine. Moreover immense quantities of the husks or pods are now thrown away, and should this fibre be found capable of being made into paper or turned to some other useful purpose, of which no doubt is entertained, it may be collected in large quantities and at little cost.

At Lubec, in the State of Maine, the small herrings which are mostly caught in weirs are pressed for the oil they afford. A hogshead of herrings will yield five to ten gallons of oil, worth 70 to 85 cents per gallon. The herrings, when brought from the weirs, are salted very heavily, being kept in the brine twenty-four hours or longer. The fishermen say this process of salting tends to separate the oil from the fish. After the fish are salt enough they are put into boilers of the capacity of a barrel, larger or smaller as the case requires, and thoroughly boiled or cooked, thence transferred to the press, which is of sufficient power to express the last drop of oil from the fish. The oil, water, &c., passes from the bottom or bed of the press, which is water-tight, to tubs so arranged as to catch the whole. The oil rises and is dipped off into barrels. The pumice (as the fishermen call it), or the remains of the fish after being pressed, is sold to farmers, who use it on grass and tillage land with good effect. A light sprinkling on grass land will give a large crop of grass for two years. A large quantity of it proves injurious to both crops and soil, as practical observers state. The herring-oil business is of recent inauguration, but adds very largely to the profits. Formerly the small herrings were spread on the grass lands, or lost entirely; now the whole are used.

The Waste Vegetation of the Sea.—The economic uses of sea-weed are increasing from time to time. For ages they have been applied in many countries to fertilise the land, and in many localities are used as food, raw or prepared. They are of importance in the manufacture of kelp and iodine, and they have also several other industrial uses.

The first important applications of sea-weed was made about the middle of the last century. It consisted in burning them for the ash, as a source of soda; but barilla from abroad entered our market, and the tall chimney of the alkali-works rose up in competition against them, and

sea-weeds were again at a discount. Then the discovery of iodine was made, and the burning of sea-weeds became a necessity; and even now we are mainly indebted to this humble source for the means we possess of borrowing the sun's light to paint his own image. Nevertheless, it must be admitted that the chemistry of sea-weed has been but imperfectly studied, and by far the greater part of the rich wreck of marine vegetation annually deposited on our island shores and the coasts of other countries remains unappropriated.

The best sea-weeds are stacked in Jersey; a dozen stacks of "drift-weed," thatched over, are common objects in a farmyard, and small barns are given up to its storage when dry. The value set on sea-weed may be judged of by the fact that the inhabitants of Sark, having none on their island, import it in fishing-boats from Herm, five miles distant. Fifty Guernsey and Sark boats may be seen at once at Herm engaged in this traffic; and those who are acquainted with the precipitous nature of the rocks of Sark and its dangerous currents will appreciate the value of vraic in that island.

There are many hundreds of acres of cultivable land on the sea coasts of all countries which might be rendered eminently productive by the fertilising substances which the tide is periodically throwing up, but which are too frequently despised or overlooked. The generous bounty of the sea places at the feet of the husbandman her richest treasures, and invites him to partake with freedom; but, instead of embracing the proffered riches, he drives his team to some distant town to purchase at a high rate what the watery element offers without price. By the use of sea-weed in several parts of the kingdom the value of land has been increased in sixfold proportion, from the circumstance of the occupier having access to this manure. On the south-east coast of Fife it is laid on the stubble at the rate of twenty cart-loads an acre, and ploughed in. The clover-crop never fails, and this is a crop requiring much phosphate of magnesia—an important constituent of sea-weed ash. In the Isle of Lewis, twenty tons of sea-weed are considered ample manure for a Scotch acre. In the Isle of Arran the Duke of Hamilton assigns to each of his tenants a certain portion of the sea-shore, according to tho

extent of his land, from which he may collect sea-weed for manure. The farms on the Lothian coasts let for twenty or thirty shillings more rent per acre owing to the tenants having a right of way to the sea-coast, where the weed is thrown ashore.

On the coasts along the west of Ireland the poorer classes are almost entirely dependent for the cultivation of their potatoes on the drift-weed cast on their rocky shores by the frequent gales of wind. After a storm they may be seen congregating in numbers from the surrounding country, with horses and cars, or with panniers; and the poorest, who cannot afford the assistance of a donkey, are themselves bearers of burdens, eagerly collecting what is thrown up and carrying it beyond the reach of the tide. The kinds preferred for potatoes are the large and succulent *Laminaria*, and when these are abundant, other kinds are neglected. These are often carried many miles into the interior, and being mixed with sea-sand, form an excellent manure, which must, however, be used quickly, as it very soon decomposes, and the gases it gives birth to are consequently lost to the ground if it be suffered to lie open.

On many shores the vegetable harvest of the deep is as anxiously looked for and as carefully attended to as that of the land; and indeed the last is often dependent on the former for its abundance.

In the Channel Islands the value of sea-weed ("varech" or "vraic," as it is there called) is considered so valuable, that special laws are enforced for its regular collection and fair distribution amongst the agriculturists, many of whom use no other. "Point de vraic, point de hangar" (no sea-weed no corn-shed), has passed into a local proverb. The sea-weed obtained is of two kinds—drift-weed ("vraic venant"), and cut-weed ("vraic scié"). The former is the most valuable, consisting chiefly of *Laminaria digitata* and *L. saccharina*, very rich in iodine and salts of potash. It is allowed to be raked up and collected all the year round. This is the constant employment of the cottagers on the sandy bays of Guernsey and Jersey, and the collection is at its height in stormy weather. The work is very laborious, the large wooden rakes used being often torn out of the hands of the vraicqueurs by the waves.

The weed is either thickly spread on the land and ploughed in fresh with a deep plough, or dried on the beach and burnt on the cottagers' hearths as fuel—certainly not on account of the cheerful appearance of the fire, or its pleasant odour, but because the charred ash thus produced sells at 6*d.* per bushel for manure. The fire smoulders quietly; it is never extinguished, but constantly renewed, and the whitest of all. smoke ascends night and day from the rude chimneys of these humble dwellings. The *vraic scié* is the weed cut off the rocks at low tide, consisting principally of *Fucus vesiculosus*, *F. serratus*, and *F. nodosus*. The time of cutting it is fixed by law, at Guernsey, from July 17th to August 31st; and at Jersey twice a year, commencing March 10th and June 20th, and lasting about ten days each time. The summer cutting is made a regular holiday in both islands, and to the young vraiqueurs of both sexes it is an occasion of great festivity. It is computed that about 30,000 loads of sea-weed are annually obtained from the rocks and bays of Guernsey and the adjacent small island of Herm. The quantity collected at Jersey is probably quite equal to that obtained in Guernsey; but more seems to be burnt and less ploughed in.

For the manufacture of kelp and iodine, marine plants offer a large revenue to man.

Kelp is an impure carbonate of soda, mixed with the sulphates and muriates of potass and soda, and with some combinations of iodine and extraneous matter. It is prepared by merely burning the weeds, previously dried, in pits dug along the shore, till they are reduced to hard, dark-coloured cakes, in which state it is sent to market. On our shores the species used for this purpose are, *Fucus nodosus*, *vesiculosus* and *serratus*, *Laminaria digitata*, *saccharina*, and *Chorda filum*; but all the larger *Fucaceæ* are applicable. The crop is gathered in the summer, dried and collected like hay, and towards the end of the season burned.

Kelp is the only commercial source for the production of iodine, and its immense value in photography, and medicine particularly, has given an impulse to the manufacture of kelp, which renders it by far the most important of all the applications of sea-weed.

As at present carried on, it has many disadvantages; these are well known to chemists; but probably from the

fact that it is conducted on desolate shores, at a considerable distance from centres of civilization, it has not yet received that attention its importance demands.

The manufacture is at present limited to a few parts of Great Britain, the western and northern islands of Scotland, the north-west coast of Ireland, and Guernsey.

The manufacture is carried on by two large associations —the British Sea-weed Company of Glasgow, and the Marine Salts Company of Ireland, at Dublin.

The discovery of the potash-salts at Stassfurt have very much modified the conditions of manufacture of kelp from sea-weed. Now that the price of chloride of potassium has been reduced by two-fifths what it formerly was, iodine, by a natural consequence, has considerably risen in price.

Improvements have been made in the former processes in use by Messrs. Cournerie and M. Moride in France.

The quantity of soda varies with the weed operated upon, and the localities where it is gathered. Messrs. Cournerie state that laboratory experiments show the soda which they operate upon contains 42·13 per cent. of saline matters, and as they obtain 40, it may be calculated that there is a loss of about 5 per cent. of the soda which the weed ought to furnish. These salts contain on the average in 100 parts, 36 of salt, 14 of sulphate of potash, and 49 of chloride of potassium. Careful analysis shows that the crude soda contains 5 kilogrammes of iodine to the ton, of which 4·07 is obtained.

This is pure iodine, which is sublimated in a suitable apparatus, maintained at a heat of 107° by a salt-bath. The loss of iodine is therefore about one-fifth—but this is a notable improvement—per ton. Years ago only about 2 kil. 7 per ton was obtained. Each ton of sea-weed kelp produces in fact 400 grammes of bromine. It is not only in the separation of the salts of the kelp that iodine is lost; it suffices to state that iodide of potassium dissolved becomes alkaline, to understand that it disengages in absolute loss a certain quantity of iodine during the combustion of the sea-weed, and experience has verified this reduction. M. Moride prevents, to a certain extent, this loss by the process which he has carried on for some years in the works where he utilises the marine products

of the Isle of Noirmoutiers, and which he has founded at Nantes.

The sea-weed collected during the day is suspended to a support of iron wire, which resembles a cage of crinoline. A certain quantity of the weed, preserved in a dry state, is set fire to on a metallic grating, placed in the interior of this iron cone, which produces a fire maintained by the fresh sea-weed. The heat disengaged is used for drying and carbonising the sea-weed which surrounds the lateral surface. This carbonisation takes place without material loss of either iodine or bromine, and without changing the sulphates into sulphur, the presence of which is inconvenient in the subsequent treatment of the products.

The charcoal made daily on the coast winter and summer is used next day at the works, and by this daily purchase gives regular employment to the population. Thus supported it can proceed with but small outlay of capital. The Isle of Noirmoutiers furnishes weekly more than 3500 bushels of this charcoal.

It is lixiviated in apparatus in a methodic manner, and the residue, compressed with peat, forms bricks, which are used as fuel, and it is also employed in the manufacture of manure. It contains a little nitrogen, a little phosphate and much *débris* of shells.

The solution is evaporated by steam, an improvement introduced by M. Moride. It is brought into the state of molten liquor, and the iodine precipitated by sulphuric acid strongly nitrous. This iodine solution is agitated in closed vessels with petroleum, boiling above 120°, known as benzine in commerce, although it contains scarcely any of this body. It is not necessary to follow the other chemical and manufacturing processes, the description of which is foreign to the subject of this work.

The price of iodine has very much risen of late years. It is now used in the fabrication of a popular dye, and this will increase the demand beyond the capacity of supply abroad. Iodide of potassium—so popular as a therapeutic agent—is now so costly as to be almost beyond the reach of physicians, and the photographic artists also suffer from the rise. Although iodine is manufactured from several species of sea-weed, it must be remembered that the plants get it from the waters of the ocean. In order to

show how sparsely the element is contained in sea water, it may be stated that, although the starch test for iodine is so delicate that one part dissolved in 300,000 parts of water is easily detected, yet if we concentrate sea water to the one-hundredth of its original bulk, it affords no characteristic reaction.

It is evident, therefore, that the proportion of iodine in sea water must be less than one part in thirty millions of water. It requires more than thirty million pounds of sea water to furnish the marine algæ with one pound of iodine, and yet one house in Glasgow manufactures thirty or forty tons of iodine from the weeds every year, and some French firms also large quantities.

The production of kelp in the United Kingdom is not more than 10,000 or 11,000 tons, of which about 6000 is made in Ireland, and the rest in the Western Islands and the Orkney and Shetlands. This quantity represents about 200,000 tons of wet weed, an amount which, large as it seems, is insignificant compared to the immense masses of sea-weed annually deposited on the coasts of Great Britain and Ireland. The best drift-weeds appear to be torn up from the Atlantic, as they are found chiefly on the western coasts of the Channel Islands. Many thousands of tons of sea-weed of various kinds are deposited annually on the coasts of England, but a small portion of which is utilised.

In France Messrs. Tissier of Finistere are the principal manufacturers of iodine and potash. About 24,000 tons of kelp are made annually in France, of which they make more than one-fifth.

The seven chief factories at Le Conquet, Granville, Cherbourg, Montsarac, Pont-l'Abbe, Portsall, and Quatre-vents make annually from sea-weed the following products:—

	lbs.
Iodine and Iodide of potassium	120,000
Bromine and Bromide of potassium	5,000
Chloride of sodium	5,000,000
Chloride of potassium	2,500,000
Sulphate of potash	1,100,000
Nitrate of potash	2,500,000

Messrs. Tissier and others supply large quantities of impure chloride of sodium for the use of the glass works, and as a flux for the potteries, and of chloride of potassium

at 92 per cent. for the manufacturers of saltpetre and alum.

The process usually followed is sufficiently simple; the kelp is lixiviated with water, and the solution evaporated; the sulphate of potash deposits first in small crystals, and then the chloride of sodium; these are separately collected, and the solution is then run off into iron coolers, where a crop of crystals of chloride of potassium is deposited in three or four days. The process is repeated with the mother liquor, and after the second crop of chloride of potassium is crystallized out, the mother liquor is very dark, and contains sulphides; oil of vitriol is added to decompose them, and much sulphur is precipitated; this is one of the bye products of the factory. The liquor, after the addition of the sulphuric acid, is decanted from the deposited sulphur, and distilled with binoxide of manganese in leaden retorts; the iodine sublimes, and is received in earthen vessels.

The present yield of iodine from good drift-weed kelp appears to vary from 8 to 14 lb., but the low quality of drift-weed kelp produced in the islands of North and South Uist and the county of Donegal does not yield more than from 4 to 6 lb. per ton of 22½ cwt. The bad quality of the kelp of Uist is accounted for by the large admixture of sand from the shores of those islands. It is probably also much mixed with inferior sea-weeds. The sea-weeds principally collected and used are *Laminaria digitata*, *L. saccharina*, *Fucus vesiculosus*, *F. serratus*, and *F. nodosus*.

The products usually obtained from a ton of kelp are shown in the table on the next page.

Many of the analyses of sea-weed hitherto published have been performed on different kelps, and as these always contain the ash of several species, little dependence can be placed on them as an index of the relative composition of any one species. The plants experimented on by Mr. Stanford, and the results of which I give, were carefully selected. The amount of iodine will be seen to be exceedingly small in the *Fucus vesiculosus*, and kelp made from that sea-weed alone would be valueless. It would yield only ·99 lb. per ton; but practically it always contains the ashes of others sufficient to bring it up to about 4 lb. per ton. Sarphati estimated the iodine in this species

SPECIES.	Laminaria digitata.	Laminaria saccharina.	Fucus vesiculosus	Fucus serratus.	Fucus nodosus.	Average.
	cwt. lb.	cwt. lb.	cwt. lb.	cwt. lb.	cwt. lb.	cwt. lb.
Chloride of potassium ..	6 56	8 20	2 72	4 96	4 46	5 35
Chloride of sodium	6 45	5 53	6 78	5 24	7 41	6 25
Insoluble ash	3 89	3 103	4 63	6 38	5 53	4 92
Iodine	0 12·77	..	..	..	..	0 5
AND OF LATE YEARS THIS HAS BEEN ADDED BY MR. STANFORD'S NEW PROCESS.						
Volatile oil..	$4\frac{3}{4}$ galls.	$4\frac{1}{2}$ galls.	$9\frac{2}{3}$ galls.	$6\frac{1}{2}$ galls.	not estimated.	$6\frac{1}{4}$ galls.
Paraffin oil	$4\frac{3}{4}$ galls.	$5\frac{1}{6}$ galls.	$13\frac{1}{5}$ galls.	$7\frac{1}{3}$ galls.	$14\frac{1}{3}$ galls.	9 galls.
Naphtha	3 galls.	$2\frac{3}{4}$ galls.	$5\frac{2}{3}$ galls.	$2\frac{1}{2}$ galls.	not estimated.	$3\frac{1}{2}$ galls.
Sulphate of ammonia ..	1 cwt. 46 lb.	2 cwt. $17\frac{1}{4}$ lb.	2 cwt. $32\frac{1}{2}$ lb.	2 cwt. $38\frac{1}{2}$ lb.	3 cwt. $108\frac{1}{2}$ lb.	2 cwt. 48 lb.
Acetate of lime	$17\frac{1}{2}$ lb.	21 lb.	75 lb.	$36\frac{3}{4}$ lb.	not estimated.	37 lb.
Colouring matter	$2\frac{3}{4}$ lb.	$5\frac{3}{4}$ lb.	$11\frac{1}{2}$ lb.	6 lb.		$6\frac{1}{2}$ lb.
Pure charcoal	8 cwt. $35\frac{1}{2}$ lb.	8 cwt. 59 lb.	15 cwt. 10 lb.	14 cwt. 41 lb.	20 cwt. 49 lb.	13 cwt. 39 lb.
Gas (approximate)	3615 c. feet.	2771 c. feet.	4313 c. feet.	3811 c. feet.	8272 c. feet.	4456 c. feet.
Iodine	19·39 lb.	..	..	..	..	5 lb.

to be ·001 per cent. That for *Laminaria digitata* corresponds to 32 lbs. of iodine per ton of kelp.

Mr. E. C. Stanford, F.C.S., who has long occupied himself practically and theoretically on this subject, suggests, and has indeed, in his own British Seaweed Company, Glasgow, carried out the following improvements :—

1. Sea-weeds of all kinds are to be stored under cover; they should be first collected in heaps, to drain off the superficial water, and then laid out in drying sheds; in summer, advantage may be taken of the sun's rays. Sea-weeds, when laid out thin, are not so difficult to dry as is generally supposed, and when dry keep perfectly well under cover.

2. The sea-weeds thus dried are then to be compressed into cakes, by hydraulic or other pressure; this is not essential, but the cakes occupy less room in stowage, and if the charcoal obtained is to be used for fuel, this treatment improves it.

3. The cakes, or the unpressed weed, are then to be distilled at a low red heat, in iron retorts; the tar and aqueous products to be collected in suitable condensers, and the gas in a gasometer. The gas may be employed for heating the stills used for rectifying the products, for heating the drying sheds, or even for lighting the factory; it might even be treated according to Pettenkofer's method of superheating, and used as a means of lighting a district.

4. The charcoal is to be lixiviated and treated as ordinary kelp, and then thrown out in heaps to dry in the air. When raked from the retorts it should be allowed to fall into the lixiviating water, or into iron boxes, to protect it from the air; if the latter plan be adopted, the heat may be rendered available for drying the weeds by wheeling them into the drying shed. The lixiviation will require larger tanks for its conduction than those at present employed, on account of the greater bulk of the charcoal; it has the advantage, however, of floating on water, and as the charcoal, when saturated, sinks to the bottom, it is quickly replaced by a fresh portion, and the solution is thus rapidly effected. The solution should be roughly evaporated to dryness, and the salt thus obtained sold to the lixiviator.

5. The washed and air-dried charcoal is to be used for heating the retorts and evaporating the solutions of the salts. Should, however, peat be very abundant in the neighbourhood, this charcoal may be manufactured into manure, by treating it with the ammoniacal liquid; or be applied to some of the many uses for charcoal, and the peat employed as the fuel. The ash from the charcoal is a valuable manure; it usually contains over 20 per cent. of earthy phosphates. The phosphates of magnesia predominate, and these are partially soluble in water. The proportion of phosphate is about that in Peruvian guano, and if the crude ammoniacal salt obtained by distillation were added in the proportion of about 40 per cent., a manure would be obtained worth from 10*l.* to 12*l.* per ton, of which from 3 cwt. to 4 cwt. would be sufficient for an acre of land. The phosphate of magnesia it contains points to its special application to beet-root and clover. Mixed with about 5 per cent. of the chlorides of potassium and sodium, it would be equally beneficial to other root and cereal crops. Liebig divides crops, according to their wants, into three classes—potash plants, lime plants, and silica plants; such a manure contains the food for all or either of these.

Mr. Stanford also suggests an important use of sea-weed charcoal as a deodorizer for dry closets instead of earth. Sea-weed charcoal he considers to be preferable, because it is the most porous, the best absorbent, and the cheapest. It only requires one-fourth of the weight, compared to earth; and when the mixture is removed and placed under cover, it soon dries. This mixture can be stored for any length of time, and used again several times. When convenient, it is re-burned, like the char in sugar refineries, except that this process is carried out in apparatus which admits of collecting the ammonia and other products condensed. The whole of the ammonia is thus collected; whilst the phosphoric acid, potash, and mineral matters accumulate in the charcoal, together with the carbon from the organic constituents of the excreta. The weight of the charcoal is increased to the extent of about 5 per cent. with each using, and, if dried and re-used five times, about 25 per cent. with each re-burning. With this constant addition, the char does not require replacing with fresh

material, so that its cost is only a primary outlay—the ultimate result being that the excretum is deodorised by a charcoal derived from itself, and a company working this process would, in addition to securing the whole of the ammonia, become sellers of a charcoal second only in value to that from bones, to the extent of, in Glasgow, if the process were general, 19 tons a day, or 6935 tons a year; the total quantity of excretum which Glasgow has to remove being 385 tons a day, and its value, at 29*s.* 6*d.* per ton equals 569*l.* The ultimate result being the same, any charcoal may be used at first. The process is carried out without odour from the closets to the finished products. Of course, the process may be modified; for instance, suppose the char to be used five times, and only dried, the addition to its value would be as follows (I take equal parts, as this charcoal will absorb at least an equal weight of even urine):—

1 ton seaweed char, at 2*l.* } = 30 cwts. manure at 9*l.* 7*s.* 6*d.*
5 tons excreta, at 29*s.* 6*d.* } = 6*l.* 5*s.* per ton.

Or, if reburnt, it would yield 25 cwts. of charcoal, and the whole of the nitrogen would pass over in the distillation as ammonia. Dr. Wallace estimates the cost of reburning char in sugar refineries at 3*s.* 6*d.* per ton for labour and fuel, containing 31 per cent. moisture, which would be much over that referred to. Here, then, we have a simple process for recovering the whole of the value from excreta, of general application, and the results of which can be predicted by chemists with absolute certainty, as far as those products to which we at present attach value are concerned; but the uncertain portion is, as usual, the most interesting, for in the destructive distillation of excreta we are exploring a new field, which promises great interest. This process is now in practical working by the Carbon Fertilizer Company.

6. The products of distillation from sea-weed he recommends to be treated as follows:—

The tar is siphoned off, and distilled with an equal measure of water in an iron tar-still; the light volatile oil passes over the condensed water, on which it floats. This is decanted, and treated with dilute sulphuric acid, which removes picoline and other oily bases, and the red colouring matter is deposited. This substance is washed and dissolved in spirit, and the solution deposits it on evaporation.

The light oil is then agitated with from 5 to 10 per cent. of oil of vitriol, washed with water and caustic soda, and finally re-distilled. The residual tar, from which the light oil has been removed, is then pumped into another iron still, and a stronger heat applied. The paraffin oil is thus obtained, and purified by oil of vitriol, caustic soda, and re-distillation. The residual pitch may be employed for the manufacture of patent fuel, &c., or pumped while hot into brick ovens provided with an iron pipe to carry off the heavy vapours, and subjected to a red heat, by which a further portion of paraffin oil is obtained, and a good coke left in the still, commercially valuable to ironfounders, on account of its freedom from sulphur. The liquid in the condensers, being separated from the tar, which sinks to the bottom, is mixed with excess of lime, and distilled in a capacious iron still provided with a suitable condenser. Ammonia and naphtha pass over, and are received into hydrochloric acid. The solution of acetate of lime remaining in the still is run out, evaporated to dryness, and the black, impure acetate thus obtained purified by charring, re-crystallization, distillation, or conversion into acetate of soda. The ammoniacal distillate which has been neutralised by hydrochloric acid is re-distilled till the specific gravity of the distillate rises nearly to that of water. This is best distilled by the agency of steam. The first portion which comes over is the naphtha; this is collected separately, the weaker liquor subsequently distilled being returned to the still with the next charge. Re-distillation over quick lime yields it in a state of purity. The solution of chloride of ammonium remaining in the still is run out, evaporated, crystallised, and the crystals sublimed according to the ordinary method of making the sal-ammoniac of commerce.

This process offers the following advantages:—

1. Retention of the whole of the iodine.

2. Easy and rapid lixiviation, colourless solutions and pure salts.

3. Absence of sulphur compounds in the mother liquor, great saving of oil of vitriol, and no evolution of poisonous gases.

4. Factory, to a great extent, self-supporting, having its own means of heat and light, the fuel being extracted from the weed itself.

5. Manufacture continuous, affording employment to the kelpers all the year round, and at a higher rate of remuneration.

6. Extension of the manufacture, as this process allows a much larger margin for profit, and admits of the lucrative working of the commonest weeds, which will not, I anticipate, be allowed to rot on the shores of Great Britain when their commercial value becomes known.

Considering the great value of sea-weed as a source of potash, and the only available source for that valuable element iodine, it is not a question as to whether they should, or should not, be collected and worked, but it is an absolute commercial necessity that the iodine and potash should be extracted from them, and in the most improved and scientifically economic manner. The spirit of alchemy is still amongst us and it presides over the extraction of valuable products from cheap and apparently useless materials. Sea-weeds have been regarded in the latter class, but now chemical researches, and enhanced prices, will add to their intrinsic value.

Various attempts have been made to manufacture paper from sea-weed, but they have not been attended with any very great success. In 1820, a patent was granted in Denmark for making paper from sea-weed, said to be whiter, stronger, and cheaper than any other paper. In 1828, a patent was taken out in the United States, by Elisha Collier, for making paper from *Zostera* or *Ulva marina.* In 1833, a patent was granted in France, to Mons. Tripot, for making paper from sea-weed. On the 20th of June, 1855, a patent was provisionally registered by Messrs. G. Martinoli and O. de Lara for paper from sea-weed, and another in the same year to Charles Mabury Archer for his manufacture of paper and "the production of textile fabrics" from sea-weed, but neither of these patents was proceeded with. L. H. Spooner also took out a patent in England for making paper pulp from grass wrack (*Zostera marina*). Paper and paper pulp from sea-weed were shown in the Belgian court of the London Exhibition in 1862.

M. J. E. Bujot, of Toulon, thus describes the process necessary to make sea-weed into paper:—"It is first necessary to pound the root part of the *Alga*, to break off a kind of bark or outer coating which covers it, and which does

not bleach effectually. The sea-weed is then to be washed, to remove the sand and earth often found adhering, and it has to be well beaten. The whole is then placed in a reservoir of water mixed with sulphuric acid. Sea-weed is naturally tough and stiff, owing to the number of cellules which it contains; to render it supple for paper-making it must, therefore, be steeped in an acid bath. In taking out the stuff from the reservoir it should be removed with a wooden spade pierced with holes, so that the acid water may be preserved for use again. The paper pulp may be placed in osier-baskets to drain off the moisture. The filaments of the leaves should not be employed for white paper, as they do not bleach well. After cleansing and treating with the acid as already described, it only remains to bleach the material with chloride of lime till it is of the whiteness required.

The aborigines of Australia were wont to employ the great leaves of *Sarcophycus potatorum*, folded into the form of a pouch, for the purpose of keeping a quart or two of fresh water; and similar uses are assigned to *Durvillea utilis* on the coast of Chili. Fishing-lines are often made of sea-weed on the north-west coast of America, and those of the Aleutians, made of the stipes of Fuci, are often forty-five fathoms long. The cylinder is sometimes used as a siphon for letting off the water from their canoes, a use to which it is well known the *Ecklonia buccinalis* is often applied at the Cape of Good Hope. In the Kew Museum there are sea-weed trumpets made of the stems of *Laminaria buccinalis*, Lamouroux.

The old stems of *Laminaria digitata* are applied occasionally to the making of knife-handles. A pretty thick stem is selected, and cut into pieces about four inches long; into these, when fresh, are stuck blades of knives, such as gardeners use for pruning or grafting. As the stem dries it contracts and hardens, closely and firmly embracing the hilt of the blade. In the course of some months the handles become quite firm, and very hard and shrivelled; so that, when tipped with metal, they are hardly to be distinguished from stag-horn.

About ten years ago a patent was taken out by Mr. Thomas G. Ghislin for utilising sea-weed in making imitation horn, moulded for the handles of cutlery, for sticks,

picture-frames, book-covers, and other purposes. It was a very pretty and novel application, and was rewarded by a medal at the London Exhibition of 1862. Although earried on energetically for some time at Hatton Garden, London, the manufaeture seems to have dropped out of notiee.

A manufaeturing ehemist, Mr. John Carrington Sellars, of Birkenhead, has invented a novel eomposition of matter for use in the place of coal, eannel, &e., in the manufaeture of illuminating gas. It eonsists of a mixture of sea-weed, sea-grass, sea-wrack, or the like, with eoal-tar, piteh, bitumen, mineral oils, &e., either with or without peat, eharcoal, or other earbonaeeous matter, which mixed matter is subjected to destructive distillation in retorts.

The advantages elaimed are more effective separation of the light hydrocarbons; second, inereased yield of earburetted hydrogen, and the production of eoke particularly valuable in the manufacture of metal-founders' blacking.

In the eountries adjoining the Baltic, in Holland, and elsewhere, the ribband sea-grass, *Zostera marina*, the "alva" of the upholstery shops, is largely used for thatching, as a paeking material, and for stuffing upholstery. The French Government some years ago ordered the systematic gathering of it on the coasts of Normandy and Brittany, to serve as wadding for eannon. The weed was washed and dried, to prevent the absorption of moisture; it has the advantage of being elastie and incombustible, and keeps the iron cool. During the eotton famine this marine plant was suggested as a good eotton substitute, but the suggestion was found impraetieable. It has often been tried, however, as a paper material.

At the London Exhibition of 1851, a mat made of this dried sea-grass was shown intended for the use of florists and botanists. It was manufaetured at an institution established by the corporation of Den Helder, in the Netherlands, for the employment of the poor. This sea-wraek has some medicinal virtues in popular estimation, but they are of questionable existence.

A French engineer, M. Lagout, proposed the employment of the sea-weeds that exist in great abundanee in the salt lakes of Languedoe and Provenee as a lining for roofs and walls. He states that among the useful properties

possessed by these marine plants are the following:—They are bad conductors of heat and cold, and, when pressed into a compact mass, of sound also. They are almost incombustible, and, even when they do burn, never produce a flame, but smoulder until they gradually and spontaneously become extinguished; lastly, they afford no harbour to vermin. In the south of France the inhabitants of the top floors of houses are obliged to resort to a variety of expedients to keep down the temperature of rooms when the sun shines; and, in fact, the upper story under the roof is seldom inhabited. It is suggested to place a thick layer of these marine plants between the roof and the ceilings of the rooms, which will not only prevent the transmission of heat during the summer, but will also, during winter, prevent the penetration of cold. In the side-walls layers of algæ are proposed to be built up for the same purpose, and also to prevent the transmission of sound. The sea-weeds are in all cases to be freed from saline particles.

Glancing next at the medicinal virtues of sea-weed, we find that they have long been held in repute as iodine, the powerful substance now obtained from them, still is.

The ancients derived all their remedies for diseases of the glands from them.

From these ancient times to the present, the juice of the sea-weed has maintained a certain degree of celebrity as a remedy in glandular diseases, and in general and local debility, at one time being highly extolled, and again sinking into neglect on account of the difficulties attending its use, but never entirely losing its good name, and still continuing to be used, to some extent, by the bathing-women and nurses at most watering-places.

Nor is it in this country alone that the sea-weed has maintained its ancient celebrity. The inhabitants of the Alps, who are afflicted with goître, a disease consisting of an enlargement of the glands of the neck, chew the stem of a particular species, which they carry about with them as a remedy; and the stems of *Sargassum bacciferum* are used by the inhabitants of South America for the same purpose. The North American Indians burn sea-weed to ashes, with which they cure swellings of the glands, like the vegetable Ethiops formerly used; and the Siamese have so great an

esteem for it, that they mix it with their famous betel-nut, which they are almost continually chewing.

Mannite, or marine sugar, is obtained from many sea-weeds. When some marine algæ are dried in the open air, they produce this efflorescence on their surface.

Dr. Stenhouse has determined the quantity of mannite in some sea-weeds as follows:—

Laminaria saccharina	12 to 15 per cent.
Halidrys siliquosa	5 to 6 "
Laminaria digitata	4 to 5 "
Fucus serratus	rather less.
Alaria esculenta	about the same.
Rhodomenia palmata	2 to 3 per cent.
Fucus vesiculosus	1 to 2 "
Fucus nodosus	nearly the same.

This production of mannite appears to be always the result of a peculiar fermentation, the effect of which is to deoxidize the vegetable mucilage and convert it into mannite.

I have not yet done with the economic uses of sea-weed, for many species furnish supplies of food to different nations. The Agar Agar of the Eastern Archipelago, the Ceylon Moss, the large commerce in edible sea-weeds in Japan and China, our own Carrageen or Irish moss, and dulse, laver, &c., are instances of the extensive applications of sea-weed for food.

Researches directed especially to the algæ as food would doubtless widely extend our present number of edible species. But many of them would require much cooking and flavouring, in order to induce the national palate to acquire a taste for them. Perhaps by the aid of good condiments and a good appetite, all kinds of sea-weed might be made palatable, verifying the good old Scotch proverb, "If you boil *stanes* in butter, you may sup the broo."

John Bull, although so truly a man of the sea, certainly does not take kindly to an Algine diet, and there is no doubt, if it can be shown to his entire satisfaction, that a lucrative manufacture of chemical products can be conducted wherever there are sea-weeds, hitherto esteemed useless, he would prefer vegetables grown in an ordinary garden, to dulse, laver, or any such marine delicacy, particularly if the sea-weeds can, by any means, be coined into money.

The principal sea-weed in which any commerce has been carried on in this country is the Carrageen, or Irish moss of the shops, furnished by *Chondrus crispus* and *C. mamillosus.*

Besides its use as food, it is employed by dyers and calico-printers for dressing the warp of webs in the loom, for sizing pulp in the paper-maker's vat, by brewers for clarifying beer; and it is also much used in England and Ireland for live stock. Of all algæ these are the most extensively used in England for food, as a demulcent and nutritive jelly. The fronds, boiled down to a gelatine, strained, and used as a substitute for isinglass in the manufacture of blanc-mange, were at one time a fashionable remedy in consumptive cases. It is still more or less prescribed here, and in France and America, as food for invalids.

The Government of Saxony has published an official statement of its properties, in which the following passage occurs:—"Six pounds eleven ounces boiled with fourteen times its quantity of water, and baked in this state with thirty-nine and one-half pounds of flour, produced one hundred and eleven and one-half pounds of excellent household bread. Without this addition the flour would not have produced more than seventy-eight and three-quarters pounds."

Irish moss contains 79 per cent. of a peculiar gelatinous principle, called carrageenin, which differs from ordinary gum in not being precipitated by alcohol; from gelatine, by affording no reaction with tincture of galls; and from starch-jelly, by giving no blue colour with tincture of iodine. It is precipitated by alcohol, acetate of lead, and infusion of galls, and converted into grape sugar by boiling with dilute sulphuric acid. The market supply is principally obtained from Clare, and the west of Ireland. It grows in immeasurable abundance along the whole Atlantic coast of America, from Nova Scotia to Long Island; and yet a few years ago quantities of it used to be sent from Europe to the United States—which was something like sending coals to Newcastle.

In 1870, an American (and the Americans are, after all, more enterprising and energetic than we are in pushing new industries) patented the preparation of what he termed

Sea Moss Farina. Why he continued the misnomer "moss," I am at a loss to discover. However, in a pamphlet issued by Mr. W. J. Rand, of Brooklyn, New York, the patentee, he states that the sale of the new food has been unprecedented, creating a consumption of more than three tons of moss per day, and employing constantly over five hundred persons in its preparation. The following is given as the process of curing the moss.

Great care having been taken to gather none but good, clean moss, free from minute shells and tape-grass (for upon this the mosser reckons his price per pound), the process of curing is immediately commenced. Hand-barrows are used to transport the moss to the top of the beach, where it is spread upon the bleaching bed to dry. Like bleaching linen at the spring, it must be alternately wetted and dried until the proper degree of whiteness is attained, particular care having been taken to remove every foreign substance.

The washing is executed in tubs, which are the size of a half-hogshead, and placed on the banks of the creeks which intersect the marshes or approach the beach. Salt water alone must be used, as the moss is very soluble in fresh: in washing all floating pieces of tape-grass are picked out, and the moss itself well rinsed. The water is now drained off, the moss transferred to the bleaching beds, where, if the weather be fine, after undergoing six washings, turnings, and pickings, it is regarded as merchantable.

The mosser watches his moss during the bleaching process with the same care that the farmer does his clover or hay. After it has been thoroughly cured it is cocked up snugly like hay, and covered with canvas.

The Chinese are evidently the sea-weed consuming nation, and of all the soft submarine plants there is hardly one but what the Japanese will also eat. The fishermen's wives wash, sort, and sell them, and they are likewise very dexterous in diving and bringing them up from the sea-bottom at great depths. The *Laminaria saccharina*, when cleansed and dried, is eaten, but it is very tough either boiled or raw. In the latter case, cut into strips and folded in little squares; a considerable number of these are usually strewed on the small tables or salvers, on which the presents, so common with the Japaneso, are offered. These presents, generally of trifling value, are always

accompanied with a complimentary paper (so called) folded in a peculiar manner, and having slips of this fucus pasted to both ends of it.

Comboo (sea-weed) is a most important article of export from Japan: it is extensively used by the Chinese, principally as a substitute for salt. Large shipments are made from the port of Hakodate. It is divided into three sorts—the best coming from Shimani and Yokadsu, the second quality from Akish, and the third from Kusudu. This article appears in the Hakodate market throughout the whole year, with the exception of the winter months, and has two crops—the first from September to December, the other from May to August. The average prices paid in 1864 were: first quality, 2·45 to 3 dollars; second quality, 2·40 to 2·80 dollars; third quality, 2·25 per picul. Cut sea-weed, also an article of consumption among the Chinese, was shipped from the same port to the extent of 4508½ piculs, valued at 15,624 dollars.

The exports of sea-weed from Hakodate in 1862 were 4,174,027 catties, valued at 70,566 dollars.

In Kanagawa in August, 1864, the prices were: fine green sea-weed, 6 dollars; large, 4 dollars; small brown, 5 dollars; large, 2 dollars 80 cents.

I give some statistics to show the commerce in this article. In 1856, 110 piculs were imported into Canton, valued at 2 dollars the picul. Between the 1st November, 1858, and the 23rd May, 1859, 8690 piculs were shipped from the single port of Nagasaki to China.

There is a good business carried on with sea-weed to China from Nagasaki and Kanagawa, the price being 3 to 3½ dollars for cut, and 1½ to 2 dollars for uncut. In 1860, the exports from Kanagawa were 26,050 piculs, valued at 9141*l.*; in 1861, 16,472 piculs, valued at 4636*l.*; and in 1862, 13,105 piculs, valued at 4250*l.* From Nagasaki, in 1861, 51,227 piculs, in 1862, 85,188 piculs.

Osaka monopolizes nearly all the sea-weed.

In 1863, 114,095 piculs of sea-weed were imported at Shanghae, and in 1864, 130,233 piculs, nearly all of which was again re-shipped to various other Chinese ports. At Tientsin, 4077 piculs were received in 1864 direct from Japan, and 6387 piculs from Shanghae and Swatow.

The trade in Japanese sea-weed has year after year been

assuming more ample dimensions in China. In 1861, the three Yang-tszc ports together took but 49,910 piculs; whilst, in 1864, 115,655 piculs arrived in Hankow alone. Ningpo also produces sea-weed, of which 613 piculs reached Hankow in 1864. Japanese sea-weed is reckoned superior to Chinese: it varies in quality, and when retailed, the price ranges from 89 to 80 cash per catty. Sea-weed is principally made use of by the poorer classes. Whilst no inconsiderable proportion is consumed in Hankow, large quantities are transported to Hsiang-tan and Chiang-sha in Hunan, and Sha-sheh, in Hupei. In 1864, two vessels arrived at Hankow direct from Japan with cargoes of sea-weed. The exports from Hakodate, in 1864, amounted to 119,055 piculs of comboo, valued at 293,620 dollars, and 4508½ piculs of cut sea-weed, valued at 15,624 dollars.

The following more recent figures will give an idea of the commerce carried on in sea-weed at the various Chinese ports. They are merely the imports in piculs for the quarter ending June respectively, in the several years—

Year.	Shanghae.	Tientsin.	Chifoo.	Kiukiang.	Chinkiang.
1869	8,748	7,591	2,421	3,001	246
1870	16,692	6,702	7,216	2,554	521
1871	40,420	10,881	17,606	5,864	617
1872	22,082	12,948	10,585	4,886	705

Many marine algæ contain such large quantities of mucilage, that some naturalists have endeavoured to make use of this product in the arts. Thus Brown (' Edin. Phil. Journal,' xxvi. p. 409) found that by prolonged ebullition with dilute sulphuric acid this mucilage was converted into *arabine*.

The gelatine or mucus differs greatly in consistency in different species of algæ. In *Gigartina*, *Chondrus*, &c., it is so firm as to give those plants the consistence of cartilage; and in these it is immediately dissolved in hot water.

Under the incorrect name of Japanese isinglass there has been occasionally imported into London from Japan a quantity of prepared sea-weed of two kinds: the first having the form of compressed, irregularly four-sided sticks, apparently

composed of shrivelled, semi-transparent, yellowish-white membrane; they are 11 inches long by from 1 to $1\frac{1}{2}$ inch broad, full of cavities, very light (each weighing about three drachms), rather flexible but easily broken, and devoid of taste and smell. Treated with cold water, a stick increases greatly in volume, becoming a quadrangular spongy bar, with somewhat concave sides, $1\frac{1}{2}$ inch wide. Though not soluble in cold water to any important extent, the substance dissolves for the most part when boiled for some time, and the solution, even though dilute, gelatinizes upon cooling.

The second kind resembles the preceding in all its properties, but its form is very different, it being in long shrivelled strips, about one-eighth of an inch in diameter. These strips, when immersed in water, speedily increase in volume, and are then seen to be irregularly rectangular. The price of this sea-weed isinglass in Kanagawa, in 1864, was 28 dollars the picul. This substance in colour is usually whiter than the preceding; it is also more readily soluble, clearer, and altogether a more carefully manufactured article. The substance under notice, in all its forms, is used by the Europeans in China as a substitute for true isinglass, for which many of its properties render it highly efficient. That which is, perhaps, most distinctive, is its power of combining with a very large proportion of water to form a jelly. This property is due to the principle named by M. Payen *gelose*, of which the Japanese sea-weed product mainly consists. The jelly formed by boiling this sea-weed product, or crude gelose, in water, and allowing the solution to cool, requires a high temperature for fusion, differing in this respect from a jelly made of isinglass, which readily fuses and dissolves in warm water. This character occasions a peculiarity in the taste of culinary jellies made of the new material, inasmuch as they do not dissolve in the mouth as ordinary animal jelly. The jelly of gelose is but little prone to undergo change; so little, indeed, that sometimes, under the name of *sea-weed jelly*, it is imported to this country from Singapore, sweetened, flavoured, and ready for use, and in this state it may be kept for years without deterioration. Gelose differs from animal gelatine in not precipitating tannic acid; from starch-jelly, in not being rendered blue by iodine; from gum, by its insolubility in cold water and its great gela-

tinizing power. From the mucilage of *Chondrus crispus*, named by Pereira *carrageenin*, it appears to differ chiefly in its power of combining with a greater amount of water to form a jelly, which is not the case with carrageenin.

Of the botanical origin of crude gelose, or Japanese isinglass, and the mode of its preparation in Japan and China, we are not yet well informed. M. Payen finds it may be extracted from many species of sea-weed, but especially from *Gelidium corneum*, Lamouroux, and *Gracilaria lichenoides*, Greville; the former of which yielded in his experiments to the extent of 27 per cent.

One part of gelose dissolved in 500 parts of boiling water will afford, upon cooling, a colourless, transparent jelly; thus forming ten times more jelly than a like weight of the best animal gelatine. In order, therefore, to produce a jelly of equal consistence, it would be only necessary to employ the tenth part of what is necessary when isinglass is used. Jellies prepared from *Gelidium corneum*, *Laurentia papillosa*, and other species, are much used for food in China, Japan, &c.

It appears, however, that several other sea-weeds are also employed by the Chinese, some of them on account of their gelatinous qualites; such as, *Laminaria saccharina*, Lamouroux, *Porphyra vulgaris*, Agardh, and a species of *Gracilaria*, apparently *G. crassa*, Harvey (Alg. Zeylan.). Another sea-weed, largely collected in the Indian archipelago for exportation to China, and which is one of the species known as agar agar, is *Eucheuma spinosa*, Agardh.

The bamboo lattice-work for lanterns, in China, is covered with paper, which, when saturated with the gelose of sea-weed, is similar to our paint. It is also used as a varnish, and as a size in the manufacture of silk and paper; and is preferable to flour for making paste, as insects avoid it.

Uses of Megass or Cane Trash.—In all the tropical sugar-producing countries there is a large quantity of squeezed sugar-cane stalk which remains to be got rid of, and which passes under the name of megass or bagasse, and in some of the English colonies is called "trash." Whatever the quantity of sugar contained in the cane, one-third generally remains in the squeezed stalk after it has passed through the mill-rollers. It contains a very large proportion of carbon,

and is consequently well fitted for conversion into manure. It is very generally used, after it has been spread out and dried on the ground, as fuel for boiling the sugar. This sugar-cane trash has often been recommended and tried as a paper material. Cattle and swine are fed upon the leafy tops of the cane, which are chopped off before they are passed through the rollers of the crushing-mill.

I have already alluded at page 211 to some of the uses of the marc or residue after pressure of the grapes; but I find that it is considered on the Continent an excellent food for stock, either simply washed or dried by heat. It is good alike for sheep, pigs, cattle, asses, mules, and horses. It may be kept either in casks, tanks, or simply in trenches, with a little salt sprinkled over it. France alone produces 25 millions of metrical quintals of this marc, which might supply half the nourishment for 3,250,000 head of cattle, and furnish 334 million pounds of good meat, nearly the fifth part of the French consumption; and 8 millions of cubic metres of manure, less the straw, could fertilise 400,000 hectares of land, a fifth part of the cultivable soil.

Roasted grape-seeds are also used as a coffee substitute.

Of all possible occasional additions to the ordinary feed of milch-cows, M. Flocking, of Dirschauerfelde, finds that none has so marked an effect in increasing the yield of milk as common molasses. The quantity given by him to each cow was a pint daily, and the consequent increase in the yield of milk varied from a pint to a quart per cow, at times when a decrease to about the same amount is ordinarily looked for, namely, in the four to eight weeks before calving. At other periods the increase was greater, *cæteris paribus*. The cost of each portion was less than a penny—the article being procured in bulk from a neighbouring sugar manufactory. The mode of giving it to the cows was by mixing it with their rape-cake in water.

In France, carbonate of potash is manufactured from the residues of molasses after fermentation. After taking out the sugar, or as much as possible, and fermenting the uncrystallized sugar, the residuum from the fermentation (*vinasse*) is evaporated and calcined, and the different salts separated in a very complicated manner. The principal product of this manufacture in the end is carbonate of potash, an extremely valuable article; but up to some

years ago it was not possible to obtain that substance in sufficient purity by this process, owing chiefly to the presence of the cyanide. The cyanide of potassium was in itself a most disagreeable ingredient if it was not completely destroyed, and in trying to destroy it, the result was that carbon was formed in the modification of graphite, and it was quite impossible to burn the potash sufficiently white. It had a grey colour, and was not marketable, or rather only marketable at a very low price. The furnaces are calcining furnaces, and are constructed rather differently from our carbonating furnaces. The working door is exactly opposite the firehole, and the fire escapes through a flue at the top, just above the working door inside. After a certain time the salt gets to that point that it will be impossible to destroy the cyanides, so as to burn out the carbon completely, without fluxing the salt at the same time, because the carbon would be there as graphite, and it is quite impossible to burn it out at a temperature at which the carbonate of potash does not fuse. When it has arrived at that stage, the furnace-man fills his furnace with a thick smoke. He then suddenly opens the working door, which is right opposite the fire, and thus burns the smoke throughout the furnace; and it appears as if, by a kind of infection, perhaps by the local heat produced right through the salt itself, the cyanide is completely destroyed, and also the graphite burnt off. The product coming from this process is a most beautiful white carbonate of potash of great strength.

There appears to be another new use of molasses. The 'Cincinnati Gazette' announces that "pure essence of coffee" is now made in that city out of the "cheapest, dirtiest molasses." The molasses is boiled, cooled, and when hard is broken and pulverized. Ground rye is then mixed with it, and a small box of the mixture, labelled "pure essence of coffee," is sold for eighty cents.

But some more clever dealers have tried to palm off artificially-made coffee, prepared from the exhausted grounds themselves. Recently, before the Tribunal of Correctional Police, Paris, two men were condemned to six months imprisonment, who had invented a substitute for coffee, which they called "exotic grains," manufactured from the dregs of the real article, purchased from cafés,

mixed up into paste with flour and water, shaped into berries, and then roasted. The composition was sold to grocers at 1 fr. 60 c. per kilogramme, and the books of the culprits showed that a ton and a half had been disposed of in the trade. Twelve grocers were at the same time condemned to a month's detention for selling coffee mixed with this compound.

Another enthusiastic Frenchman proposes to utilise the coffee-grounds, now wasted, by consuming the solid parts, as well as the infusion of the berry, as the Turks do. Under the head of "A Reform in the use of Coffee," he writes as follows to a French scientific periodical:—

"The object that I recommend with a profound conviction drawn from the remarkable work of Professor Payen, is the utilisation without residue of the torrified coffee-bean. The comparative studies of coffee and cocoa show a striking analogy in the chemical composition of these two products, and the consumption of the entire grain seems quite as reasonable for coffee as for cocoa. The profession in some countries has lately devoted itself to carry out this idea, for the Orientals drink at the same time as the infusion, the powder which has served in its preparation. The deficiency of alimentary resources in face of the growing wants and consumption has often occupied me, and the idea of giving the public a great part of the nutritive principles lost until now, has determined me to leave the purely speculative part, and to try some experiments in preparing various products containing coffee without residue, combined with purity and quality.

"To enumerate the loss of nutritive matter which is occasioned by the habitual method of making coffee, it is sufficient to state that the importation of this precious bean into France, which in 1830 was 18,500,000 lbs., reached in 1862 the enormous figure of 60,000,000 lbs., which, large as it may seem, has since been exceeded. This quantity is equal to 48,000,000 lbs. of torrified coffee. When we carefully prepare an infusion of coffee, we only extract 20 per cent. of the substances which compose the bean; and that which we throw away under the name of "grounds" still contains 80 per cent. of the primitive matter employed. In deducting 34 per cent. for the *cellulose*, we find that 46 per cent. of substance is lost, that is nearly half, or

more than 20,000,000 lbs. for France alone. In this calculation we have still overlooked a quantity of highly coloured liquid which impregnates the grounds when thrown away. Without doubt the residue compared with the part dissolved in the infusion does not possess an identical importance, but it still contains nutritive matter of an incontestable value, namely, nitrogenous matters, fat, and above all mineral salts, which are very useful for the nutrition of the bony, muscular, and nervous system (sulphates, chlorides, phosphates of potash, chalk, and magnesia). These calculations, based upon the learned analyses of the chemist Payen, do not require any other comment for instructed men to understand the importance of the utilisation without residue of the coffee-bean. The best arguments are often incapable of convincing the mass of the people, and bringing about a reform in their tastes and habits; thus to make our idea popular we are obliged to present our product under several forms, capable of answering to the numerous varieties of tastes, and we offer to consumers the impalpable flour of coffee, tablets of coffee and sugar, and tablets or croquettes of coffee with cocoa-butter. The flour is prepared by the aid of a very powerful vertical mill, which turns slowly, to avoid raising the temperature. This powder, which has lost nothing of the subtle aroma of the coffee, is, perhaps, for domestic use, more advantageous than the tablets. The tablets of sugar and coffee contain absolutely only these two substances; the tablets of coffee with cocoa-butter are prepared with or without sugar; the first resembles chocolate very much, and like it can be consumed as it is, and under the form of an alimentary beverage with milk or water; the second, richer in coffee, is used in smaller quantities, and further, leaves the consumer to sweeten to his taste.

"Before the learned analyses of Messrs. Paysié, Chenevix, Cadet de Vaux, Robiquet, Rocheleder, Boutron, Frémy and Payen, and the researches of Messrs. Bouchardat, Gasparin, Fonsagrives, Welter, Marvaud, &c., coffee was considered as a diffusible stimulant, and its richness in nitrogenous principles, as well as its remarkable action upon the intimate phenomenon of nutrition, were but very imperfectly understood. It is now known that a well-made infusion of torrified coffee contains nearly one-third of an

ounce of nitrogenous matter per quart, and that the drinking of this beverage abates the combustion of the tissues; but it seems to be still ignored, that the grounds thrown away as a residue without value, contains a very rateable proportion of nutritive principles, and that it suffices to use without waste the residue in the coffee-pot, to grind it like cocoa or corn, to an impalpable powder. Coffee finely pulverised is in effect the base of all preparations without residue, and when we would try our products in really economical conditions, it is necessary to mix with water, or milk, the powder, kept in motion by the movement of the cup or the spoon. The presence of pulverised coffee in milk or water modifies at first the taste and aspect of the beverage, and causes repulsion in certain delicate or distrustful persons; but at the end of a few days they get accustomed to this new aliment, of which the nutritious qualities are soon shown by use. It is in coffee with water that the powder brings about a remarkable change, and I do not doubt but that the limpid infusion will be for a long time preferred by the connoisseur, to the coffee called à l'Orientale; but it must not be forgotten that I aim rather at usefulness than *pleasure*, and above all recommend my productions for the preparation of coffee with milk, excepting in the case of its use for the army and the marine, to make that which is commonly called coffee soup.

"Everyone knows how feeble ordinary coffee with milk is in its aroma, very often modified by the addition of chicory; with coffee-flour you can instantly prepare a more substantial and more aromatic breakfast by mixing with boiling milk the fine powder, which will give the beverage the consistency of good chocolate. But to obtain from the coffee all its nutritive value I think it preferable to mix the powder with milk and water cold, and then to put the liquid on the fire. Under these conditions the coffee is penetrated with water little by little, its extractive parts are completely dissolved, and the insoluble matters detach themselves, and more easily become assimilated. If you take the precaution to serve it up immediately the ebullition commences, it will retain all its aromatic qualities.

"The tablets of coffee and sugar can be used in the same

manner as the powder; they are, perhaps, a little less aromatic, but their nutritive qualities are not in the least abated. The Military Board could, under an enlightened and faithful control department, make tablets or rations of sugar and coffee in powder as they now make bread and biscuits, and these products, put into metallic boxes, would defy all damage. In point of view of the required torrification, the transport and the distribution, they would realise an incontestable economy; their use would obviate the necessity of buying and keeping coffee-mills in the regiments.

"What has been said of tablets of sugar also holds good with the croquettes made with cocoa-butter, of which the addition augments the nutritive qualities of the coffee.

"In terminating this article I would desire to have it observed that my preference in favour of the use of coffee without residue is not only based upon theory, but that I have often proved by experience the results foreseen by analysts. However, by reason of the inseparable difficulties in all physiological experiments, I would not be too positive, but invite the friends of progress to verify my assertions, and to throw a new light upon a subject which seems to me far from being exhausted."

Thus much for our French enthusiast. I leave his idea to work its way in public favour. We shall next have some projector recommending the grinding up and imbibing the whole leaf of the tea instead of merely drinking the infusion, and thus economising the waste of the 123½ million pounds of tea-leaf consumed in the United Kingdom. Next to the Chinese we are, perhaps, the largest consumers of the eastern leaf, the average annual consumption per head of the population being 4 lbs. We imbibe the smoke of about 43 million pounds of tobacco-leaf annually, and we consume without any waste 7¼ million pounds of cocoa, even the husky shells or "miserables" as they are termed, being ground up and infused by some of the poorer classes.

Fungi are a waste wild product of nature, collected and utilised in various countries. The Chinese import immense quantities dried from different countries. The ear fungus (*Hirneola Judæ*) is exported largely from New Zealand by the Chinese immigrants. The natives of

Australia eat the butogo and broycgo, a species of edible fungus, but will not touch the common mushroom. In Europe great use is made of mushrooms in cooking, and they are cultivated in England and France. The *Agaricus campestris* and *A. oreades*, the mitre mushroom, and the small delicate morell (*Morchella esculenta*, and the *Cantharellus cibarius*) are among the finest of our edible mushrooms. The best way of preserving them for use is to string them in rows, and after they become flaccid, to hang them in a dry place, where they can have plenty of air. They then form a delicious ingredient in rich gravies, stews, &c. There is a large commerce in truffles, another wild fungus the *Tuber cibarium*, found in the earth beneath trees, especially oaks, beeches, and hawthorns.

A very large number of the fungi are poisonous.

In Siberia the fly agaric, *Amanita muscaria*, is swallowed as a narcotic, and gives insensibility to pain without interfering with consciousness. The common puff-ball stops all muscular action, but leaves the perceptive powers untouched. Some rules or test are very desirable to determine the edible from the poisonous species, and the following hints may be worth attention. In the first place the true mushroom is invariably found in rich pastures, and never on or about stumps, or in the woods; and, although wholesome species sometimes occur in the latter localities, it is better to avoid their products. A very good point, in the second place, is the peculiar intense purple-brown colour of the spore-dust, from which the ripe mushroom derives the same colour (almost black) in the gills. To see these spores, it is only necessary to remove the stem from the mushroom, and lay the upper portion with the gills downward, on a sheet of writing-paper, when the spores will be deposited, in a dark impalpable powder, in a short time. Several dangerous species, sometimes taken for the true, have the spore umber-brown or pale umber-brown.

In the true mushroom, again, there is a distinct and perfect collar, quite encircling the stem, a little above the middle, and the edge of the cap overhangs the gills. In some poisonous species this collar is reduced to a mere fringe, and the overlapping margin is absent or reduced to a few white scales. Lastly, the gills never reach to nor touch

the stem, there being a space all around the top of the stem, where the gills are free from the stalk.

There are numerous varieties of true mushrooms, all of them equally good for the table. Sometimes the top is white and soft as kid leather; at other times it is dark brown and scaly. Sometimes on being cut or broken, the mushroom changes colour to yellow, or even blood-red; at other times, no change whatever takes place. To sum up, it is to be observed that the common mushroom always grows in pastures; always has dark, purple-brown spores; always has a perfect encircling collar; and always has gills which do not touch the stem, and has a top with an overlapping edge.

In addition to the method just indicated for testing the genuineness of mushrooms, it may be added that, however much any particular fungus may resemble the eatable mushroom, none are genuine or safe, the skin of which cannot be easily removed. When taken by the thumb and finger at the overlapping edge, this skin will peel upward to the centre, all around, leaving only a small portion of the centre of the crown to be pared off by the knife.

Mushrooms, except such as are specially named in the list of apothecaries' stuffs, are prohibited to be imported into Russia and Poland, but are admitted free to the Trans-Caucasian ports of the Black Sea. Dried mushrooms may be imported, however, we are told, through the Custom-houses of Poland, on payment of a duty of 40 copecks per pood, on express permission of the Governor (Lord-Lieutenant) of the Tsaardan. Those who have read the remarks of Dr. Langsdorff, Cooke, Greville, and others, will see that this edict is levelled chiefly against the narcotic fly agaric or *Amanita*, which is used in Asia and parts of European Russia for the same intoxicating purposes as spirits, wine, or opium, are by other nations. They are collected in the hottest months, and hung up in the air by a string to dry; some dry of themselves on the ground, and are far more narcotic. The usual mode of taking the fungus is to roll it up like a bolus and swallow it without chewing. When steeped in the juice of the whortle-berry, or great-bilberry, its effects are those of strong wine. One large or two small fungi is a common dose; to produce a pleasant intoxication for a whole day, particularly if water be drunk after it, which augments the narcotic principle.

The effect comes on from one to two hours after taking the fungus.

In Russia and Poland mushrooms form a most important part of the diet of the common people; whole tribes in Russia are mainly supported by them, scarcely any species being rejected. Even those kinds which are elsewhere refused by common consent, as poisonous on account of their extreme acridity, are taken with impunity, being extensively dried, or pickled in salt or vinegar for winter use.

A scientific gentleman who was detained as prisoner in a town of Poland, amused himself with collecting and drying the various fungi which grew within its walls, amongst which were many commonly reputed dangerous; to his great surprise his whole collection was one day devoured by the soldiers. Persoon quotes a letter, where the writer states, that in consequence of seeing the peasants about Nuremberg eating raw mushrooms, seasoned with anise and carraway seed, along with their black bread, he resolved to try their effect himself: and that during several weeks he ate nothing but bread and raw fungi, and drank nothing but water, when instead of finding his health affected, he rather experienced an increase of strength.

But if dried mushrooms are prohibited, in Russia they may be imported as well as truffles and champignons, &c., in oil, vinegar, or pickle, at 62*s.* the cwt. by sea, and one-third of that charge by land.

Mineral Waste.

I now pass on to treat of the economic applications and uses, proposed or applied, for the many residues of mineral substances, and the industries that have sprung out of these.

Waste Coal.—The first, and, perhaps, the most important, is the utilisation of waste coal or coal-dust, and the secondary products of gas-works, &c.

At the present moment, of the millions of tons of coal burnt in manufactories, steam-boats, ranges, open fire-places, and fixed boilers, often one-half, and sometimes three-fourths, is absolutely wasted and lost. This applies more especially to domestic use, a very large and increasing

one, in which it can be easiest shown. Fire, as we all know, radiates heat equally in all directions. A fire placed in the centre of a room gives equal heat at the north, south, east, and west. Now, our habit in the United Kingdom, where fuel has always been abundant, is to place the fire in the wall of one side of the room, so that, if in the north wall, all the people south of it get one-fourth of the heat, and the other three-fourths go into the wall —to the north, east, and west, or up the chimney. In town houses, which are built in a row, the waste is less, as each house warms his neighbour's in a degree.

The less coal that there is consumed, the cheaper it will be, and all manufactured articles of iron necessary will be cheapened; while the more it is wasted, the more we shall have to pay for these manufactured articles, and the less the consuming public will have to pay for butter, meat, and farm produce. Waste is one of the great faults of our country; it has descended to us from a period when the common necessaries of life were abundant, and the population small and not accustomed to those luxuries which all classes now have come to regard as necessaries.

Coal being a natural product, our only mode of cheapening it is by a strict regard to economy in getting and using it. To waste coal is to injure the State. Coal may be wasted in the getting and in the using, and the Report of the Royal Commissioners on Coal shows that in both respects a large and lamentable amount of waste is going on. The Committee which had charge of that particular part of the inquiry reported that, "under favourable systems of working, the ordinary and unavoidable loss is about 10 per cent., whilst in a large number of instances, when the system of working practised is not suited to the peculiarities of the seams, the ordinary waste and loss amount to sometimes as much as 40 per cent."

Mr. J. P. Baker, a Government Inspector of Mines in the South Staffordshire coal-field, describes the difference between the "pillar and stall" method of extracting coal, and that known as the "long-wall" system of working. In that district the pillar and stall system is the more general of the two, and is the plan which has been pursued, with very few exceptions from time immemorial. A large quantity of coal is thus crushed and destroyed, and thousands

of tons are annually consumed in the waste heaps at the pit's mouth. The entire quantity of coal left in the mine, and irrecoverably lost, was stated by this witness to be from one-third to one-fourth of the whole. Generally speaking the roof is coal and is left, the thickness of which varies from one to four or five feet.

One reason why the better system has not come more rapidly into vogue is stated to be, that the pillar and stall plan gives a greater proportion of large coal. But there is a deficiency in quantity, and it is found that coal of a smaller size answers equally well, while the total quantity brought to bank is greater by the long-wall system than by the other. In the iron districts small coal is much more extensively used now than formerly, and it may be hoped that by degrees the great waste of small coal and slack will be diminished. A quick though wasteful method of getting the coal is that which seems the most approved. A temporary advantage is gained, but the natural resources may be said to suffer. The employment of coal-cutting machines and other appliances may be expected to economise the material and the cost of getting it.

Actual exhaustion must be a very remote event, but the consequences of waste may be felt at a comparatively early date, in a higher price, and, perhaps, an inferior quality.

The "utilization of waste" is the most useful and important department of invention, and one which may lead to some means, other than the dust-fuel furnace, of employing to advantage the immense quantity of coal-slack now of little or no value to anyone. But to do this will require a more thorough attention to the character of the material, and the behaviour of its compounds when put in the fire, than seems to have been commonly accorded by experimenters in this department.

The most obvious, and most practised method of converting comminuted coal into solid fuel, is to mingle it with some adhesive and combustible substance like bitumen, pitch, tar, or rosin, and thon mould it into cakes by pressure. This would do very well were in not that the more inflammable cementing hydrocarbon burns out first, and lets the less combustible carbon of the coal fall

in powder through the grate. This may be avoided by mingling the dust in the first instance with clay, which is done in Germany to the extent of 30 or 40 per cent. of clay, but this compound burns slowly, and requires a larger furnace for the production of a given quantity of heat, and leaves a great residue of ash. By a peculiar method of working, not explained, and doubtless somewhat expensive, an experimenter at Nashville, Tennessee, has reduced the proportion of clay to 8 per cent. The thoroughness of manipulation required to reduce the clay to this extent must necessarily be somewhat costly, and at the best the method includes the addition of inert matter that, to say the least, is in the way of the furnace. It would be better if some material capable of combustion, with about the same rapidity as coal, were used as the uniting substance. It is possible that peat might subserve this purpose, and, if so, this much-lauded, but rather unreliable fuel might find a much more practicable use than has hitherto been found for it.

One difficulty experienced with the blocks of coal and clay, is the facility with which they absorb moisture—a drawback remedied in the more recent methods of manufacture, by coating the blocks with a waterproof liquid made of rosin dissolved in benzine in the proportion, by weight, of six of the former to one of the latter—something more than 20 lbs. of the waterproofing being required per ton of coal. Taking into consideration all the minutiæ of manufacture incident to the solidification of coal refuse, it seems doubtful whether this will be able to compete with, on the whole, the simpler method of consuming the waste in a dust-fuel furnace, so called. Still there is evidence to support a different conclusion as concerns the slack of coal, west of the Alleghanics, in the use in France and Belgium, of twelve hundred thousand tons of fuel composed of bituminous slack and coal-tar.

Our colliery produce cannot last for ever at the enormous rate at which we are working the mines, and as the quantity of small waste coal per annum in the United Kingdom has been estimated at 28,000,000 tons, the utilisation of this refuse is a matter of national importance in more senses than one. Various, not very successful, attempts at making patent fuel have been attempted in this

country. The idea of utilising the dust and waste of coal is neither new nor recent, yet so enormous are the quantities of this refuse, that there is room for very many ways of profitably treating it. Very effective and valuable fuels have been so prepared by means of admixtures of tar, pitch, silicates, and other substances. Some years ago the United Kingdom Patent Fuel Company proposed to do great things in making bricks of coal-dust with farina and alkali, but the cost of the manufacture did not permit the condensed fuel to compete with ordinary coal.

On the Continent and in the United States the manufacturing efforts have been more successful. In the coal-mines of Charleroi, Belgium, 800,000 tons of coal-dust have accumulated, impairing the working of the mines, and M. Dehaynin, of Paris, and a company are working on this coal-dust. After having it pulverized and freed from all strange matter by machinery, this dust receives the forms and dimensions the best adapted for heating locomotives, by agglomerating eight parts of coal-tar with ninety-two parts of coal-dust. This mixture, heated to 300 or 350 degrees, with superheated steam, becomes a paste, which is mechanically and powerfully pressed into cylindrical or rectangular forms, and after having been cooled, solid, compact cylinders, of about five inches diameter, and weighing eighteen pounds, or prismatic blocks of about five and a-half inches by seven, and twelve high, weighing twenty pounds, are obtained. These blocks are very nearly the same density and weight as the solid coal, and they burn without interfering with the circulation of air through the grate. This new combustible is warranted not to give more than six per cent. of ashes, and is now in great demand by railway companies, on account of its greater heating power, and its being actually cheaper than ordinary coal. M. Dehaynin and the company manufacture annually 255,000 tons of this agglomerate.

Dr. J. R. Hays, of Washington, United States, has recently published a paper on a means of using up the dust-coal which lies in heaps near the shafts of most coal-pits. He mixes the coal-dust with clay and coal-tar, and estimates that the cost of these, together with labour, will not exceed one dollar per ton; and if the waste coal can be delivered in the cities at two dollars per ton, a fuel of great excel-

lence can be easily prepared at three dollars per ton, which will be an economical improvement of great importance to the poor.

The committee on science and the arts, of the Franklin Institute, to whom was referred for examination specimens of artificial fuel, prepared by Mr. E. F. Loiseau, of Philadelphia, published in 1870 the following report:—

"That they have made trials of the samples produced from anthracite and from bituminous coal.

"The mode of manufacture, as related by Mr. Loiseau, is as follows:

"1. Anthracite small coal and dust were mixed with seven per cent. of clay, and compressed into cylindrical moulds about 4½ inches in diameter and 4 inches deep, or else into spherical masses about 3 inches in diameter.

"2. The moulded masses are placed for a few minutes in a bath of benzine, in which rosin had been dissolved, and from which they are removed and dried by an exposure to a current of air.

"The object of coating them with a film of rosin is to prevent the absorption of moisture and consequent softening of the clay; the solution in benzine penetrates the mass of coal and clay to a depth of about a quarter of an inch, and so efficiently closes the crevices, that samples immersed in water for twelve hours were found dry in the interior when broken up for examination.

"Both the anthracite and bituminous fuels were burned in a furnace measuring 9 inches in diameter and 7 inches in depth: each variety of fuel burned freely, and was completely ashed, but the intensity of the combustion was less than that produced by anthracite or bituminous coals of small size, burned in the same furnace. These comparisons were made with a moderate and also with a strong draught.

"The average amount of ash obtained from the anthracite artificial fuel was 16 per cent., and from the bituminous artificial was 18·5 per cent.

"The heating powers, as obtained from trials in Thompson's apparatus, are as follows:—

"One pound of anthracite fuel, in each of four experiments, gave the results 4·30, 8·50, 7·86, and 6·76 lbs. of water evaporated, being an average of 6·85; while one pound of bituminous artificial fuel, in each of four experi-

ments, evaporated 9·35, 11·11, 12·88, and 10·61 lbs., averaging 10·99. The anthracite average is 7·40 lbs. of water. The average of bituminous is 14·88 lbs. of water.

"The non-uniformity of result is partly due to the imperfect manipulation in mixing the coal and the clay, and partly to the varying amounts of solution of rosin absorbed in the bath to which the material is subjected. The imperfect manipulation can be remedied by the adoption of proper machinery for that part of the process.

"The ability of the artificial fuel to bear transportation is less than that of anthracite or good lump bituminous coal, but the structure is firmer than that of many bituminous and semi-bituminous coals that are carried to market. The masses will generally break up with a fall of 3 feet upon a stone pavement, but are strong enough to bear ordinary handling and transportation; and should they become broken, will suffer no damage, unless exposed to wet.

"The samples of artificial fuel examined are well adapted for use for purposes in which great intensity of combustion is not desired.

"For the production of steam in stationary boilers, and for household purposes, it can be employed equally as well as any ordinary coal; and, whenever the cost of preparation is less than the cost of mining coal, this invention will make available the immense amounts of small coal now allowed to remain useless at the coal-mines. It appears to work far better than the balls or bricks of coal-dust and clay and lime that came into vogue in this city (Philadelphia) many years ago, when anthracite was brought to market without preparation by the coal-breaker, which had not then been invented; the balls or bricks thus made not having the protection from wet secured by Mr. Loiseau, by his resinous coating.

"We consider the method of preparing artificial fuel from waste anthracite and bituminous coals, as presented by Mr. E. F. Loiseau, as ingenious and well adapted to the purpose, and worthy of the attention of those interested in the production of a cheap fuel, adapted to a great variety of uses."

The samples of artificial fuel, presented to the Franklin Institute to experiment upon, were simply pressed by hand

and could not be made as solid as they will be when pressed by appropriate machinery.

The percentage of ash is larger than in ordinary coal, as the clay is not consumed; but the other advantages of the artificial fuel, in point of durability, cleanliness, and cheapness, more than compensate this small disadvantage.

The cost of manufacture at the mines, including the coal and all the materials, will, it is stated, not exceed one dollar per ton.

In connection with this report, some general remarks upon the subject may be useful.

It is commonly supposed that the primary object, in the production of artificial fuel, is the utilisation of waste; but there are other important ends that may be secured, which ought not to be lost sight of in the general consideration of the subject. One of these is the production of fuel better suited to certain industrial operations than that obtained in the crude form. The process of coking coal for iron working is a striking example in point. By this process the sulphur in the coal, which is injurious to iron, is removed, and the coke is made to approximate in purity to charcoal, with which the best iron is made.

The manufacture of charcoal is another familiar example of the artificial preparation of fuel. By this process we get a fuel which burns with scarcely any smoke, is free from substances contained in the natural wood, and is thereby much better for many uses than wood previous to distillation.

We see, then, that the artificial preparation of fuel does not necessarily look to cheapness as the sole end to be secured; in fact, this point may, in some cases, be entirely ignored with a large demand for the fuel produced, provided it has qualities that compensate for increased cost. To utilise waste and thus make a cheap fuel is, however, the chief end sought by inventors, who aim at reducing coal-slack to a form convenient to use for domestic or manufacturing purposes.

There are, probably, very many ways in which this may be done, not yet hit upon by inventors. The one described in the report alluded to is undoubtedly a good one, and there are others in use which give excellent results. One important thing in domestic fuel is that it shall be com-

paratively free from dust. A slight increase in the percentage of ash is not to be regarded as a serious defect. Such increase gives little trouble, and does not lessen greatly the heating capacity of the combustible ingredients. It adds a little to the trouble of attending fires; but this is a trifling inconvenience.

I believe that the form of the lumps or blocks of artificial fuel is a matter of more importance than it is generally considered. If made with sharp corners and angles, as is usual, these corners break and crumble in handling and transportation, and a disagreeable and filthy dust is created, which might, I think, be avoided in a great measure by a different form. Some of this kind of fuel is also not sufficiently dense to make a fire that will last a sufficient time. Others are not sufficiently tenacious in texture to prevent crushing and crumbling.

In short, there is still room for much invention in this department, and I look to see the manufacture of artificial fuel take its place, in the future, among the great industries of the world.

The Belgians, instead of wasting or destroying the powdered coal, which is seen in great quantities at the mouth of our coalpits, preserve it carefully, and, with the addition of a little clay, water, and some chopped straw to make it binding, work it up into small cakes or loaves, twice or three times as big as a French roll, and then dry them under the action of the sun and wind. A fuel is thus provided, which, besides being very cheap, makes, when used to supplement coal, an excellent fire.

Agglomeration of coal, under the patent of Sausse, Belgium, is made by a mixture of the following substances to the ton of coal, in powder: $\frac{1}{2}$ per cent. of lime, 6 to 10 quarts of ammonia, strong glue melted 20 lbs., boracic acid 2 lbs. The mixture is then pressed into moulds as usual.

The processes for the utilisation of the anthracite waste coal in America consist universally in the employment of a foreign material or materials, which shall serve the purpose of a cement to bind the loose particles of the waste together. The cements heretofore used have been both of mineral (incombustible) and of organic (combustible) character. In the majority of instances, as is usually the case with a field of invention just ripening into importance,

the patentees of such processes display a characteristic ignorance of, or lofty indifference to, the conditions of the problem they profess to solve. The number and variety of substances which have been secured by inventors, either as cements, or to aid in the cementation or combustion, is well calculated to surprise one unfamiliar with the literature—if such an expression is allowable when applied to Patent Office records—of the subject. The several alkaline substances and their silicates seem to have been held in special favour, since they repeat themselves, with some modifications, in several places. Lime, either alone or with some subsequent chemical alteration into carbonate, sulphate, or silicate, is claimed; or plaster of Paris or hydraulic cement is used directly. Clay must also be named. Among inorganic substances may be enumerated pitch, coal-tar, resin, Trinidad bitumen, asphalte, petroleum residues, dextrine, glue, grahamite, &c., while as accessories, employed either to assist cementation or combustion, we have sawdust, chaff, flour, blood, cowdung, starch, sand, saltpetre, and other substances too numerous to mention. Comparatively few of these processes have ever reached a public trial, as indeed few deserve it, and of those which have received attention none have been more than indifferently successful, either from inherent deficiencies or from commercial reasons.*

A new and rather curious method of treating the refuse coal-dust, which amounts to so large a percentage in all coal-mines, has been adopted. It is nothing more nor less than pasting the dust together with a mixture of alkali and starch! At Sunderland the price of stone coal has been as low as from 6*s.* to 8*s.* per ton. At the same place the coal-dust, prepared in cakes as above mentioned, costs only 5*s.* 3½*d.* per ton—making a difference in cost of from 8½*d.* to 2*s.* 8½*d.* per ton, or say an average of 1*s.* 8½*d.* per ton—an amount well worth saving, particularly where enormous quantities are used. Besides this, the patent coal-dust cakes possess other advantages, the chief of which is the fact that the coal-dust is utilised. They are more cleanly to handle than ordinary coal, can be stored with less loss of space—occupying only 32 cubic feet to the ton, instead of 42—

* W. H. Wahl, in 'Journal of the Franklin Institute.'

and are said to produce a brighter and stronger fire. It is also said to be smokeless, inodorous, and to leave less clinker than ordinary. With all these advantages, it will surprise me greatly if this plan be not rapidly adopted in other countries. The method of preparation is this: grind the "slack" to powder by a grinding-wheel in the circular trough of a mortar-mixing machine, and add the compound of starch, alkali, and water, in the proportion of 8 lbs. of starch and $3\frac{1}{2}$ lbs. of alkali to the ton of coal-dust. This compound is made by first mixing the farina with a small quantity of hot water, then hot water is rapidly let into the mixing-tank until the liquid has acquired the proper consistency, when the alkali is added.

In Philadelphia a company has been organized to manufacture fuel out of the dust of coal. It burns freely and thoroughly, and gives out as much heat as solid anthracite. The coal-dust can be purchased at the mines, where there are immense quantities of it hitherto unused, for the small price of 40 cents per ton, or one dollar per ton if sifted, and it is estimated by those engaged in the enterprise that a ton of solidified coal-dust can be sold at from four to five dollars.

The enormous piles of "slack" or waste coal lying contiguous to the Westmoreland Coal Company's mines are to be utilised at last and turned into coke. The Messrs. Carnegie, of Pittsburg, and others, are constructing coke-ovens along the Pennsylvania Railroad for this purpose, and it is said they will be successful, having a process for desulphurizing the fine coal. The sulphur has heretofore prevented coke being made from Westmoreland coal. There are upwards of 900 coke-ovens along the Pittsburg and Connellsville road, and the Uniontown and Bradford and Mount Pleasant Branch roads, and nearly 400 additional ones are being constructed. Some idea of the tonnage can be formed when it is known that the production largely exceeds 100,000 bushels, or about 5000 tons, of coke per day, and falls far short of the demand.

Powdered Fuel.—Nearly twenty years ago, John Bourne, speaking, in his treatise on the steam-engine, of the smoke nuisance, said: "Nearly all the expedients hitherto introduced for burning smoke in locomotives are adaptations of the devices heretofore in use for burning smoke in land-

engine furnaces. But the rapid combustion which a locomotive boiler requires renders the burning of smoke by any of these ancient devices a matter of very difficult achievement, and it seems to be indispensable that a method founded on a totally new principle should be introduced. It would appear that the fuel and the air must be fed in simultaneously; and the most feasible way of accomplishing this object seems to be in reducing the coal to dust and blowing it into a chamber lined with fire-brick, so that the coal-dust may be ignited by coming in contact with red-hot surfaces after having been mingled with the quantity of air necessary for combustion. This, however, in common with other improvements upon the locomotive, requires to be worked out." The idea of burning coal in this manner even then was not a novel one, and, since he wrote, other eminent engineers and economists have from time to time suggested the use of coal in this form, both for steam and metallurgic purposes. It needs no extraordinary intelligence to recognize the importance of the idea as applied to the use of coal.

No one is ignorant of the fact, that the combustion of a fuel is more rapid, and for most industrial purposes more economical, just in proportion to the extent of surface it presents; a handful of shavings burning more rapidly, and consequently creating a higher temperature, than would the solid block of wood from which they were made. To apply this principle to the burning of coal, it was evidently necessary, first, to design some mechanism for reducing the coal to dust—the finer the better—in order to make it expose the greatest surface to the action of the fire; secondly, to find efficient means for supplying to this coal-dust the air necessary to ensure its quick and complete combustion, and some way to introduce the combined dust-fuel and air into furnaces and fire-boxes; and the last conditions, without which the others would be of but little practical value, must be those of economy and simplicity of design—a sufficient economy after allowing a large margin for errors, and a simplicity of mechanism that would be suited to the most ordinary intelligence.

All these conditions have been fulfilled by American talent and industry; and eleven years of persistent labour has removed the dust-fuel problem from the limits of ex-

periment to the wide field of practical and most successful work. To manufacturers, the matter of economy in fuel for the purposes of steam is fast becoming a question of almost vital importance, owing in part to the general failure of a sufficient supply of water-power, and in part to the great competition among the manufacturers, especially those of cotton and woollen goods, by which the margins of profits are so reduced that, in many instances, a difference of 25 or 30 per cent. in the cost of power determines the question of profit or loss of the establishment.

There are now several large manufactories in the United States using pulverized fuel for furnaces and boilers. The system has been long adopted at the pianoforte manufactory of Messrs. Chickering and Sons, Boston, Massachusetts. I strongly recommend all manufacturers to give their attention to this matter of pulverized fuel. It is worthy of investigation, and every one interested in the economy of fuel should look into the excellent results obtained by the Storer process.

A rather singular invention for remedying the actual want of fuel in private houses became very popular in Paris during the siege. They prepared cylinders of clay impregnated with bituminous substances; these combustible cylinders were used like the ordinary charcoal which is necessary in Parisian cookery. The earthy matters, of which the proportion is not greater than necessary, remain in the furnaces like ashes left by the combustion of charcoal. It is proposed to continue the use of this kind of artificial fuel.

Culm is a first-class fuel for lime, brick, or tile burning, and also a good house-fuel when mixed with a small quantity of yellow clay and made into balls the size of a hen's egg. Mr. John Nixon, solicitor, of Barnard Castle, calls attention to a very easily made and cheap kind of fuel, which greatly economises the use of coal, and gives, when properly managed, a greater heat. It is simply clay of any kind, mixed with small or crushed coal, in the proportion of one-third coal to two-thirds clay; some use more, others less. When mixed and trodden with the feet, or beaten with a pounding-staff or mallet, it is made into balls of any size adapted to the kind of grate. The fire cannot be lighted with this fuel; but, after it has been well

set agoing, these balls can be added, dry, or even damp, and "heaped over" with a few cinders or small coals, will keep a fire hot for a long time. In a word, it is turning our fireplaces into little brick-kilns. This kind of fuel has been used in our northern dales for ages before pit-coal could reach them, their only material then for mixing being what is known as "crow coal." The fires were called "cat fires," and these mixed balls were known as "cats." Balls of clay, even unmixed with coal, increase the heat of a fire and greatly economise the use of coal. The mixed balls are more of a fuel themselves—they will last three or more days; the mere clay-balls will last as many weeks. The sizes and shapes preferable for sitting-rooms are those of a round and kidney potato; for the kitchen they are made larger.

McKenzie's patent mixture of coal and coal-oil was formerly employed at the Dublin gas-works. It is now, however, abandoned. In place of this, the coal is coarsely pulverized in a Chilian mill and mixed with coal-tar, produced upon the premises. This mixture is quite dry, and is found to work well. After a time the coal-tar from this process fails to yield any gas, when it is sold to a patent fuel company in Wales. A portion of it is also consumed upon the spot in making a patent fuel with the coke breeze, which is thus cemented into cylinders of four inches diameter and one foot in length.

A new building material is found in coal-dust. The mixture is composed of one-sixth cement and five-sixths coal-dust. In the Waverley hydropathic establishment at Melrose the experiment was tried. A series of thick sheet iron plates are stiffened at the edges with angle iron, the plates being attached to uprights of T-iron, and being kept in the proper position by pins, the plates are fixed so as to be readily raised as the building progresses. After the requisite proportions of mine-dust and cement have been mixed together, and the whole thoroughly saturated with water, the mixture is flung in between the plates, and large pieces of slag or stone bedded in it; thereafter another bed of concrete, which fills the interstices between the large pieces and thoroughly fixes them; another layer of stones or slag is then added, and so on, till the space between the plates all round the building is filled. After being allowed

to stand for a night, the concrete will be hard enough to allow of the plates being lifted in the morning. The chief feature is its extreme simplicity. When gravel can be obtained, it is of course better; but the slag refuse of furnaces and useless stones can be readily utilised in this manner, and make better houses than brick.

In 1871 we exported from the United Kingdom 341,865 tons of coke and cinders, valued at 241,419*l*., and 198,115 tons of manufactured fuel, of the value of 125,034*l*.

Attention has lately been more directed to the economy of coal for steam engines, and there is yet much room for economizing waste in this direction. In the mechanical section of the British Association at Brighton a most important address was delivered on this subject by Mr. J. F. Bramwell, C.E.

Mr. Bramwell said that in thinking over many subjects connected with mechanical science for notice, he could discover nothing more important than "coal," the staff of life of the steam-engine. He referred to the increasing drain upon the coal resources, which, however great, had a limit: the amount raised in 1855 was 64 millions, in 1860 80 millions, and in 1870 110½ millions of tons, while the price of coal in the colliery districts had advanced during the past year one hundred per cent. Unlike wood fuel, which grows year after year to replace the annual consumption, coal fuel is given us once for all, and should therefore be regarded as a precious trust of which we are the guardians and stewards, justified in using all we require for legitimate purposes, but criminal in respect of all we waste, whether through carelessness or ignorance—an ignorance as culpable as carelessness.

He next passed in consideration the various possible substitutes for coal as a source of power,—wind, the force of streams and the force of tides—pointing out various methods by which these agencies might be more fully utilised than at present. He referred to the waste of coal in mining; the duty of mining engineers to reduce this waste to a minimum; then the waste of coal when brought to the surface in domestic use and in manufacturing; the grates and chimneys in use—fire cannot burn without air, no means whatever provided for the air to come into the fire, the fire being placed below the chimney, the main

part of the heat goes up and is wasted, leaving the room to be warmed principally, if not entirely, by the radiated heat. He referred to the admirably simple fire-grate, invented by Captain Douglas Galton, which had found but little favour in England, but the merits of which had at once been acknowledged by the French, who made a careful and scientific investigation of its working, and found that with such fire-places three times the effect was obtained from a given weight of coal than could be got with those of ordinary construction. No doubt there are many other plans by which the same end may be attained, yet we go on year after year building houses without change and wasting the precious fuel.

With regard to waste in manufacturing uses, Mr. Bramwell discussed many sources of it and the remedies for them, called attention to modes of firing, construction of boilers and furnaces, and other methods of economising fuel, as well as to the wastefulness of many steam-engines made by manufacturers who are unacquainted with the principles of the art they follow, and altogether in the rear of the scientific knowledge of the day. Were all the steam-engines used in the United Kingdom improved up to the highest standard, the result would be a saving yearly of millions of tons of coal.

In marine-engineering there has already been enormous improvement within the last ten years, of some 40 or 50 per cent. in their consumption of fuel, but a large field for improvement still remains, especially in the firing and in the size of the boilers. Such great advances have been made by the unremitting attention of the extremely skilful mechanical engineers who construct these engines, that at the Cardiff meeting of the Royal Agricultural Society of England one of the engines (the prize one, that of Messrs. Clayton and Shuttleworth) ran for five hours and one minute with 14 lbs. of coal per horse-power, being therefore a little under 2 and 8-tenths lbs. of coal per horse-power per hour, and this horse was the horse-power of the dynamometer break and not the mere indicated horse-power by which marine engines and other engines are ordinarily judged. The indicated horse-power is of course in excess of that developed upon the break, as the indicated power includes all the engine friction and break friction, and if this latter

horse-power be taken as a standard the best of the engines tried by the Royal Agricultural Society at Cardiff would offer favourable comparison with even very good condensing engines, and be found to give a duty far beyond that which 10 years ago would have been thought obtainable in any but the very best. It may also be mentioned that the Cornish pumping engines, which used to be looked upon as the most economic of all engines, are doing only an average duty of fifty-three and 3-10ths millions of lbs. lifted one foot high for 1 cwt. of coals, and that the very best of them is doing only 71 and 7-10ths millions of pounds, while the break horse-power developed by Messrs. Clayton and Shuttleworth's engine at Cardiff gave a duty of 79 and 2-10ths millions of pounds. This large duty was due to the great ability in the management of the fire (as has already been hinted at) and to the proper proportion of the boiler in obtaining the steam, and to its thorough cleaning, in preserving it in the first instance, and then to the efficient utilization of that steam by high expansion in a cylinder, steam-jacketed around its circumference and at the ends. But at the very same show there competed for the prize an engine which, to the eye of the uninstructed (the ordinary purchaser for example) was as likely an engine as the prize engine, and yet this engine burnt 10 lbs. of coal per horse per hour, or nearly four times that which was burnt by the prize engine; and, moreover, it must be remembered that this wasteful engine was one which the maker thought worthy to be sent to trial. How many are there, therefore, among those which makers do not think worthy to be sent to trial, which must deal as wastefully, or more wastefully with coal, and are, for the sake of a few pounds in the first cost, bought by ignorant purchasers, who go on committing the sin of wasting coals with such engines until they are worn out, the loss becoming greater with the age of the engine.

But there remains the great class of fixed engines used for driving manufactories, which engines are, as a rule, of the most disgraceful and scandalous character. In the first place enormous numbers of them are non-condensing engines. As an excuse for this it is in many instances alleged that water is scarce, and that there is not therefore the means of providing condensation. To meet such

excuses it should be remembered that there are appliances, well known to scientific engineers, at all events, that have been in use for many years, by which condensation can be effected with no more consumption of water than is required for the feed of a high pressure engine. I allude to the ordinary cooling ponds for injection water, &c., to the surface evaporative condenser. In every instance these may be employed, and thus in lieu of sending steam into the atmosphere at a pound or two above atmospheric pressure, that steam might be condensed, and a pressure of 12 or 13 lbs. additional throughout the whole stroke of the piston might be obtained. Moreover, the interior of the boiler would be kept clean, and thus its surface would be in the best state for transmitting heat. But passing by this question of the repugnance to the use of condensing engines, and admitting for the sake of argument that non-condensing engines may be allowed, what does one ordinarily find as a type of the non-condensing engine? One finds the cylinder with a cubic capacity far too great for the work required where steam is used. Throughout the stroke one finds that this capacity is not utilized as it might be by the employment of high pressure steam and considerable expansion, and that while the steam even in the boiler is probably at only 40 lbs. above atmosphere, the governor is flying out nearly to the full width, the throttle valve is all but closed, and there is a continuous wire-drawing of the steam, so that its average pressure throughout the stroke of the cylinder is only some 15 lbs. or 20 lbs. above atmosphere. Now, when one recollects that it requires one portion of coal to get steam up to atmospheric pressure, and that this portion may be looked upon as practically constant whatever pressure of steam above atmosphere may afterwards be attained, and that if, therefore, steam at 15 lbs. above atmosphere be used, half of all of the fuel is lost, while if at 30 lbs. above atmosphere one-third only is lost, and if at 120 lbs. above atmosphere one-ninth only will be lost, in getting up steam to atmospheric pressure, one can understand how essential it is that in non-condensing engines the steam should be used at a really high pressure, and yet, I believe that if the large number of 10 or 20 horse-power horizontal non-condensing engines employed by manufacturers throughout the kingdom were examined, and indicator diagrams taken,

it would be found that their pressure upon the pistons did not average much more than 20 lbs. above atmosphere. And it is a lamentable fact that many makers of steam-engines, men who cannot be properly called engineers, men who are mere manufacturers not knowing the principles of the art they follow, will boast that their engine is doing very well, that it drives the whole of Mr. So-and-So's work, and does not require more than 30 lbs. steam in the boiler, not understanding that, if they would raise that steam to 120 lbs. and then work it non-expansively in a small cylinder they would thereby be obtaining a great economy, and if they would work it expansively in a large cylinder, that cylinder being properly steam-jacketed, they would obtain a still greater economy. I think there is so little reliable information as to the total horse-power at work in the United Kingdom (as is evidenced by the fact that very recently the number of boilers has been estimated before a parliamentary committee as low as 50,000, and as high as double and even close upon quadruple that number), that I feel it would be an unwarrantable waste of time if I were to enter into calculations, or rather speculations as to the exact saving that would be made in the consumption of coal, consequent upon improving the whole of our steam engines up to the present highest standard. It will, however, be quite sufficient to show the importance of the question for me to say, and I am sure I should be perfectly safe in saying it, that such saving would have to be estimated by millions of tons. This is a saving that might be made with our present knowledge, but when we recollect that an engine burning even as low as 2 lbs. of coal per indicated horse-power per hour is still developing only one-tenth of all the power which according to calculation resides in that coal, there is manifestly a vast scope for our mechanical engineers in the exercise of their talents for further economy. But let not consumers of coal remain indifferent to savings on their present consumption until those improvements are discovered by scientific men. On the contrary, let them forthwith do everything in their power to reduce the consumption to the extent to which present science, and in some instances present practice, show the consumption can be reduced. One is apt at first sight to marvel that users of steam-engines should be so blind to their own

interest, and should permit waste to go on day after day, and year after year, a waste not only prejudicial to the community at large and to suceeding generations, but a waste causing constant expense to those who commit it, and a waste, therefore, that one would think such persons would only be too ready to stop; but the fact is, there are several reasons why manufacturers and others permit the waste to go on. In prosperous times those engaged in manufactures are too busy earning and saving money to attend to a reorganization of their plant. In bad times they are too dispirited, and too little inclined to spend the money, that in better times they have saved, in replacing old and wasteful appliances by new and economical ones; and one feels that there is a very considerable amount of seeming justification for their conduct in both instances, and that it requires a really comprehensive and large intelligence, and a belief in the future possessed by only a few out of the bulk of mankind, to cause the manufacturer to pursue that which would be the true policy, as well for his own interest as for those of the community.

In economising the waste coal of the collieries, this manufacture supplies railways and steam-boats with fuel of good quality and easy of stowage, and also utilizes the enormous quantities of tar resulting from the manufacture of coal gas. Lastly, it gives rise to an industry which obtains from this same tar other products of immense value. From a black, oily, and almost fetid material science now obtains a series of dyes and colours of surpassing brilliancy and freshness. Phenic acid, now employed in medicine and surgery, and benzine, &c., which is used for removing stains from stuffs, to dissolve india-rubber, in the making of varnishes, and for the preservation of timber are amongst the valuable applications of coal-tar.

The Waste Products of Coal.—Dr. Edmund J. Mills, F.C.S., well observes that "the history of coal-tar and its products is not only interesting as a chemical romance, but as furnishing a striking example of the practical utility of pure or abstract research. Within the memory of many of us, tar was a repulsive nuisance which had sometimes to be stealthily removed at night, under apprehension of legal proceedings. It is now, if not the king, certainly the viceroy of manufactures; it has suppressed and created

whole branches of industry, and seems still to be unexhausted as a souree of products, the extrication of any one of which may affect the prosperity of large sections of labour."

Mr. C. Leicester in an article in 'Science Gossip,' "On the Products of Waste," thus alludes to the many substances obtained from coal:—

"In the destructive distillation of coal for the production of ordinary gas, a quantity of offensively-smelling water and a considerable bulk of tarry matter are also produced. These were formerly thrown away as useless and deleterious, but now they are utilised.

"The noxious oodur of gas-water is due to the presence of sulphur and ammonium eompounds, and by simply adding suffieient quieklime the alkaline compounds are decomposed and ammonia gas is liberated. This is eonducted into chambers filled with carbonic-aeid gas, and the common salt, known as earbonate of ammonium, is produeed. More than 2000 tons of this chemical are annually made from refuse gas-water. If, instead of quicklime, hydroehloric acid be added, sal-ammoniae is obtained, from which nearly all the medieinal preparations of ammonia are produeed. The quantity of sal-ammoniac thus manufaetured from year to year exeeeds 4000 tons. If, again, sulphuric acid be employed in the place of hydroehloric acid, sulphate of ammonium is the result, about 5000 tons of which are annually used for manures. When to a solution of sulphate of ammonium one of sulphate of aluminium is added, the crystalline substance called alum is obtained, so generally useful in the arts. The sulphurie acid used in preparing alum may also be eliminated from gas-water. The sulphur impurities are removed by means of a mixture of sawdust and iron, sulphide of iron and water being produced; air is then passed through the mixture, the effeet of which is to convert the sulphide of iron baek again into oxide at the same time separating in the form of powder. The sulphur is then burned in a properly-constructed furnace, and, by causing the fumes to combine with nitrous and aqueous vapours in leaden chambers, sulphurie acid is obtained.

"Let us pass now to the tarry matter, the other waste product of the distillation of coal. This is a very complex

body, containing a large number of substances, most of which are volatile, some acid, some alkaline, and some neutral. By appropriate chemical means these components of crude coal-tar are obtained in a state of purity. The lighter portion, known as coal-naphtha, consists principally of benzol, a liquid of great utility in the arts. By treating benzol with nitric acid, nitro-benzol is produced, which is used, on account of its sweet taste and almond-like odour, to perfume soaps and flavour confectionery. Aniline, the base of all the dyes bearing that name, is obtained from the action of nascent hydrogen or nitro-benzol. Carbolic acid is another product of the fractional distillation of coal-tar. By the action of nitric acid, carbolic acid is converted into carbazotic acid, which is now used as a yellow dye. Perhaps the most interesting of all the products of coal-tar is solid paraffin, a colourless crystalline fatty substance, which may truly be termed 'condensed coal-gas.' It is found naturally in the coal measures and other bituminous strata, constituting the minerals known as fossil wax, ozokerit, &c. It exists also in solution in many kinds of petroleum, and may be obtained by distilling off the more volatile portions and exposing the remainder to a low temperature. The greater bulk of paraffin is, however, obtained from coal-tar. The oil produced from paraffin will only burn in the presence of a wick, and is, therefore, perfectly safe; when burning, it splits up into olefiant gas, thus producing a brilliant white light. To sum up—from the two waste products of coal in the manufacture of gas are obtained carbonate, chloride, and sulphate of ammonium, sulphur, and sulphuric acid, coal-naphtha, benzol, nitro-benzol, aniline, carbolic and carbazotic acids, and solid paraffin."

Ammonia, oil of vitriol, alumina, and water, form, when combined in certain proportions, the alum of commerce. Weak ammoniacal liquids are exhausted of ammonia by heating them to a high temperature in a closed vessel, and suddenly discharging the compressed vapour into water, or weak oil of vitriol.

The utilization of ammonia in the manner here described has thrown into the market an equivalent quantity of potassic salt that was formerly employed for the same purpose. It seems probable that, up to the year 1851, the

whole of the alum manufactured in Europe was potassic alum. With the increasing rise in the price of potassic salts much attention was directed both to cheapening the process of preparation as well as the materials which were required. Now ammonia alum does not differ from the potassic species either in colour, crystalline form, or general applicability. The substitution, therefore, was silently effected; and, to this day, the bulk of the public are ignorant of the very harmless and laudable replacement. Probably the whole of the alum manufactured in England, (now more than 500 or 600 tons a week) is exclusively the product of the ammonia process.

Were the whole of the ammonia produced annually from coal in London alone to be collected in its perfectly pure and dry condition, the yield would amount to approximately three thousand five hundred tons. If all the ammonia now lost in the coke manufacture were to be utilized, instead of being wasted as at present, it could be sold to the consumers at nearly one-half of its present price.

Phenol has been applied to numerous useful purposes. Its aqueous solution has been used in enormous quantities for washing overcrowded courts and alleys, during the prevalence of epidemics. The same solution, injected into the blood-system of animals suffering from the cattle-plague, apparently acted efficiently as a remedial agent. Fish die when immersed in it, and their bodies dry up without putrefying; and animal substances of almost every kind are preservable from decomposition by its means. Hence, it is invaluable in the dissecting room; and is much prized as a surgical dressing. Albumen is precipitated by it. The virtues of tar-water, formerly so much extolled, were probably due to its containing a little of this substance.

Pure dry phenol attacks the skin and mucous membranes powerfully; and consequently, if administered internally, is a strong poison. It has a peculiar and very characteristic smell, that can hardly be mistaken. It is utilized on a commercial scale for the production of colours, the stability of which appears to be sufficiently satisfactory. Three of these may be briefly alluded to. *Peonine* is a product of the joint action of hydric sulphate and oxalate

upon phenol, under the influence of heat; it is rendered stable by digestion with aqueous ammonia. If peonine be boiled with aniline, a blue colour (*phenol blue, azuline*) is formed. When phenol is treated with hydric nitrate (*nitric acid*) a violent reaction occurs, and it is entirely transformed into "*picric acid*," a yellow dye of considerable beauty and great permanence. Like most of the coal-tar colours, it requires no mordant when applied to silk or wool, but attaches itself at once to the fabric. If, therefore, a white tissue composed of silk and cotton, be dipped in a hot solution of picric acid, and afterwards washed, each of its constituents will be readily distinguishable—the cotton by its unaltered appearance, the silk by the yellow hue it has acquired. Picric acid is very crystalline, and but sparingly soluble in water. Its metallic derivatives have of late acquired greater importance. Potassic picrate, for example, has been manufactured for some time past on a considerable scale.

Messrs. Ch. Girard and G. de Laire have recently published a work on this subject, written with rare ability, entitled 'Traité des dérivés de la houille applicable à la production des matières colorantes' (Paris: G. Masson). They are experienced manufacturers and scientific men, known by their numerous labours and discoveries.

Coal-tar was until about twenty years ago a waste product, difficult to be got rid of. Now we obtain from it a number of useful substances, among others dyes remarkable for their brilliancy as well as for the permanence of their shades. Messrs. Girard and de Laire show that the rapid progress made in this direction is due to the reciprocal influence of science and industry, occupied simultaneously on these products, the one in the laboratory, the other in the manufactory, since the discovery of violet aniline by Perkins in 1856.

Aniline.—In 1867 the German production of aniline was equal to 10,000 cwt. per year, but at the present time it has increased to 25,000 cwt. The consumption of this article in the German colour factories, however, is still larger, so that 10,000 cwt. more has to be imported. About 100 lbs. of fuchsine is produced daily, besides other dyeing matter. Methyl-aniline, heretofore fabricated only in France, is also now produced in Germany, to the extent of

10 cwt. a day. It replaces the iodine-violet, the production of which, on account of the high price of iodine, is no longer practicable. This change reduces the quantity of poisonous residue of the aniline factories, which, until now, consumed daily 30,000 cwt. of arsenical acid. This will now be limited to the production of fuchsine; but even in this direction a favourable result is expected from the experiments made in the laboratories of the German factories, to produce fuchsine without the use of arsenical acid. Two German chemists discovered that the dyeing matter of "madder" originates from carburetted hydrogen, which appears also in the coal-tar. Following up this discovery, they succeeded in making artificial alizarine from anthracene. Since 1870 this method of producing alizarine from coal-tar is adopted by most of the ten or twelve German aniline factories; there is only one factory in England and one in France. The total produce of alizarine in 1873, amounts to 22,000 cwt., of which 15,000 cwt. are made in Germany.

Of the anthracene, the raw material for alizarine, there is at the present time an abundance in the five millions of cwts. of tar produced in the gas-works. The artificial alizarine dispenses with all madder preparations, and the cultivation of madder is rapidly decreasing. At a lower price of alizarine, the import of logwood will also considerably decrease.

Anthracene, one of the hydrocarbons obtained in the distillation of coal-tar, was commercially unknown three years ago. When found as a sediment in the green grease (one of the last portions of the distillation), used as a lubricating material, it was considered a worthless residue and thrown away. The first discoverers of its utility were Messrs. Graebe and Liebermann, the former a professor at Konigsberg, the latter at Berlin. Although first announced in 1867, it was not till 1871 that it began to receive attention.

In January 1872 even its value was known to but few manufacturers, and it could be purchased commercially pure at 125*l.* a ton.

The very high prices then demanded for alizarine, principally in Russia, suddenly created a great inquiry for this article, and the present rate may be quoted at 400*l.* to

600*l.* the ton commercially pure, and during a short time of excitement it even fetched double that sum. In a short time the artificial alizarine will doubtless replace the natural dye made from madder. Within the course of but a few months twenty new manufactories of alizarine have been established. England produces more anthracene than all other countries put together; but the production is in few hands owing to patent rights. Of the new factories, fifteen have sprung up in Germany. One in Elberfeld, lately transferred to a public company, showed net profits for the year 1872 amounting to about 60,000*l.*, of which 50,000*l.* were said to be realised in the production of alizarine.

The manufacture of alizarine from anthracene may be said to be in its infancy, for the only practical use made of alizarine has been for printing various shades of violet, brown, and red. The superiority of the artificial, over the natural, alizarine has been already proved, as the fabrics need not be first mordanted, but the mordant can be mixed with the colour. A few manufacturers have already employed it successfully for dyeing Turkey red, and when this becomes general, the anthracene from coal-tar will be found insufficient to meet the increased demand.

A patent of Messrs. Versmann and Fenner, for producing anthracene from coal-tar pitch, is beginning to be successfully worked here and in America, but even this will add but little to the supply.

Various plans have been suggested by scientific men for the production of anthracene from other substances, but hitherto none has been successfully worked.

The production of anthracene for the year 1872 represented a value of fully a quarter of a million sterling, and the make for 1873 will be larger still, as many other manufacturers are entering into the production. This utilization of what was but a few years ago only a waste product turned into the sewers, is likely to restore many acres of land to grain production which have long been devoted to the culture of madder-roots. As the results of these researches, Messrs. Domeier & Co., of London and Berlin, showed at the Vienna Exhibition in 1873, anthracene in its various stages of purity: antrachinon, into which the anthracene is converted for the manufacture of alizarine;

paste, some samples of which contain 10 or more per cent. of pure alizarine; samples of fabrics and yarns printed with these colours and with anthracene blue, a newly discovered colour.

Hlaswetz finds that when dinitronaphthol is converted by the action of potassium cyanide into naphthyl-purpuric acid, indophan, a blue substance, similar to indigo, is formed at the same time.

The best method of preparing pure indophan is the following:—30 grains of dinitronaphthol with about 2 litres of water are heated to boiling, and sufficient aqueous ammonia is added to ensure complete solution. Into this a hot concentrated solution of 45 grains of potassium cyanide is dropped. In ten minutes the reaction is completed. The whole is now washed on the filter with boiling water, till the filtrate ceases to become coloured. A violet-coloured mass is thus obtained, having a beautiful green metallic lustre, and consisting of a mixture of free indophan and a potassium-compound of that body. Washed for a long time with boiling water, the latter becomes coloured from the solution of a trace of the compound; addition of potassium carbonate prevents this solution, and precipitates from the washings a brown impurity. The mass on the filter is now heated with very dilute hydrochloric acid, filtered and washed, till the filtrate is free from hydrochloric acid.

The pure dry substance is of a violet colour, and has a beautiful green metallic lustre.

The potassium and sodium compounds are obtained by treatment with solution of potassium or sodium hydrate, filtering and washing till all free alkali is removed. Both these compounds greatly resemble indigo. Indophan is insoluble in water, alcohol, ether, benzol, and carbonic bisulphide, but moderately soluble in sulphuric acid and warm acetic acid, and slightly so in melted naphalene. The solutions are purple-red; from these indophan cannot be obtained in a crystalline condition, it may, however, be sublimed like indigo. Nitric acid appears to oxidise it, forming a brown-red body, soluble in all alkaline solutions. Indophan is not reducible by lime and ferrous sulphate as indigo is. On warming it with alcoholic potash-solution, first a dark green body is obtained, and by further action

a humus-like substance is precipitated. Fused potassium hydrate gives the same decomposition products with this body as with naphthyl-purpuric acid.

We have seen that coal-tar is the basis of all the new mineral dyes now in such general use, and this field of chemical research seems boundless in extent. Thus coal-tar is gradually refined upon and improved, till the dirty mass becomes a liquid of glowing tints, which is shown by exquisite silks, feathers, and moiré-antiques, dyed with a variety of colours. Thus the coal-tar which was formerly of such little value that it almost puzzled gas factories to get rid of it, has become the basis of a most important industrial manufacture. A few grains of aniline suffice to dye many yards of fabric, and it is well that it has this power, for 2 gallons of coal-tar only yield 10 grains of aniline.

The amount realised for the residual products sold by the various gas-works of London brings in nearly half a million sterling annually; the sums obtained in the year 1871 being given as follows in the official returns made to Parliament:—

	£
Gas Light and Coke Company	115,693
Imperial Gas Light Company	116,137
South Metropolitan Gas Company	27,495
Commercial Gas Company	27,331
Independent Gas Company	22,567
London Gas Light Company	38,810
Phœnix Gas Company	43,782
Ratcliff Gas Company	7,310
Surrey Gas Company	15,267
Western Gas Company..	12,879
Total	427,271

This is exclusive of a large quantity always held in store at the end of the year. The aggregate quantity of each kind of residual product sold by all the companies in the year was as follows:—

Coke, chaldrons	919,459
Breeze "	130,229
Tar, gallons	12,330,010
Ammoniacal liquor, butts of 105 gallons ..	200,138

The ashes of gas-works are sometimes utilised by being

ground and mixed with moist lime, then slowly air-dried and moulded into bricks. In one or two weeks these bricks can be used for building purposes.

The average amounts of accessory products from the manufacture of gas by the different companies in London show the mean yield per ton of coal for all the companies (excepting the Western, which works up only cannel coals), to have been:—Coke, 24·44 bushels; cinders, &c., 3·12 bushels; tar, 9·14 gallons; ammoniacal liquor, 15·76 gallons. The cost of working up a ton of coal into gas is given as about 1*l.* 9*s.*, and the price for which the products can be sold, profits on rent of meters, &c., amount to about 2*l.* 1*s.* per ton of coal.

The sulphur obtained in purifying coal-gas is now utilised. The method introduced by Mr. F. C. Hills for purifying the gas consists in passing it over a mixture of sawdust and hydrated ferric oxide. By exposing the iron sulphide thus produced to the air it is oxidised, sulphur being separated and hydrated ferric oxide reproduced. After this operation has been repeated several times, the sulphur will amount to about 40 per cent., and the material is then unfit for the purification of gas; but is used for producing sulphurous acid by roasting it in reverberatory furnaces, so as to present a large surface for oxidation. In 1859 the consumption of this material at Mr. Lawes's factory, at Barking Creek, was 737 tons, and in 1861 it was 2180 tons. Now it is much larger. It is said to yield one-and-a-fourth its weight of oil of vitriol.

The ammoniacal liquor of the gasworks was formerly looked upon as a refuse, and, except in large towns where the quantity produced was sufficient to support separate works in which the liquor could be purified and converted into sulphate or other salts of ammonia, it was generally allowed to run to waste. It is of considerable value as a fermenting agent in dissolving bones. After being once distilled it contains 20 per cent. of ammonia, chiefly in the state of a carbonate, in which form it is liable to escape, and, in order to check the evaporation, sulphuric acid should be mixed with it. The difficulty of procuring this liquor must interfere with its extended use on the farm.

Van der Elst and Matthes, of Amsterdam, received a medal in 1862, at the London Exhibition, for the good

quality of their products obtained on a large scale by utilising the ammoniacal liquors from gas factories.

M. Rattier has lately introduced in France, for heating gas furnaces, an agglomerate composed from dust and débris from coke, which is unfit for use in the gas-retorts by reason of its pulverulent nature and inferiority as a combustible, containing as it does also a large proportion of earthy matter.

Its transformation into cakes or bricks, by combining it with a certain quantity of concentrated tar, renders it easily and advantageously used as a fuel.

The production of this dust and refuse is sufficiently large in all gas-works, representing at least in bulk one-tenth of the quantity of coal distilled annually. An hectolitre of this waste, mixed with about 18 or 20 per cent. of concentrated tar, will make say 35 bricks of 4½ lbs. each.

A gas-works which consumes 20,000 hectolitres of coal, for instance, would have about 2000 hectolitres of this dust and waste of coke, &c., to operate upon, which, at 35 bricks to the hectolitre, gives a total of 70,000, or about 280,000 lbs. of useful fuel.

These bricks or cakes can be used alone; but it is better to burn with them one-fourth their weight of coke or coal.

The employment of 280,000 lbs. weight of these bricks, with one-fourth part of coke, would serve to heat a furnace with seven retorts during a year, and the profit realised would not be less than 80*l.*, if the coke were sold only at a franc or 10*d.* the hectolitre. According to the Paris journal, 'Le Gaz,' here are the comparative results of careful experiments made on a furnace of seven retorts, distilling 2 cwts. of coal per retort every six hours:—

Consumption of different kinds of fuel in the twenty-four hours computed:—

	Kilos.
1. Bricks and coke—	
400 kilos bricks and 100 of coke ..	500
2. Bricks and coal—	
280 kilos bricks and 200 of coal ..	480
3. Coke alone	560
4. Coal alone	575

If the coke sells only at one franc the hectolitre, the compressed bricks would cost 70 cents. the 100 kilos,

reckoning the dust and débris of coke to be worth 80 cents the 100 kilos, and the tar 3 fr. 25 c. From the calculations made, it results that every gas-works can obtain, by the conversion of its coke-dust and waste coal into cakes, a quantity of fuel sufficient to replace one-fourth of the total quantity of coal used, and for ten furnaces with seven retorts each about three of them may be heated with this fuel, and a saving of at least 6000 francs (240*l.*) be realised, more especially if there be steam power on the works to form the compressed bricks.

In no country, perhaps, is less attention bestowed than in North America upon the proper economy of manufactures by saving or utilising the effete or waste products of various processes. The coal-tar and ammonia water obtained in the manufacture of gas are nearly all thrown away for want of a market, although it is well known that the one contains benzole, paraffin, naphthaline, dyes, and various other products, and that the latter is one of the most valuable of all manures. The almost total waste of the bittern, or mother water of the salines, in Virginia and Kentucky, although they are known to be rich in bromine, is another instance of the same kind. This is not from ignorance, as the facts are well known; but it must arise from the greater gains to be secured in the States by following other branches of industry. With the increase of population these evils will be remedied.

Twenty years ago, as we have seen, coal-tar was of but slight value, and often could be had at simply the cost of removal. By a process of distillation, however, a composition, or native asphalt, has been produced from it, which, besides becoming an article of commerce, has proved to be a valuable and durable adjunct in the manufacture of felt roofing, and a considerable source of income to gas companies.

More than 8,000,000 lbs. of prepared roofing felt and tarred paper are sold yearly in New England, and upwards of 40,000 barrels of compo and pitch, the products of coal-tar, used mostly in the covering of roofs—a quantity sufficient for a surface of 20,000,000 square feet, equal to 450 acres.

The works of the New England Felt Roofing Company, in South Boston, cover an acre of land, have an in-

vested capital of 150,000*l.*, and employ more than 500 men.

The principal technical application or use of coal-tar pitch on the Continent is in the manufacture of "briquettes," lumps of coal made by mixing coal-dust with the pitch or asphalt, and pressing into a form. The importance of this industry may be estimated from the fact that a single firm makes 3000 cwts. in twelve hours, and has an invested working capital of 20,000*l.*

Another interesting industrial application of asphalt is the manufacture of the so-called *asphalt-tubes.* They were invented by Galoureau in Paris, and serve to conduct cold liquids and gases. They possess the advantage of being very cheap, withstand a pressure of 500 lbs. to the square inch, are somewhat elastic, are impermeable to water, are poor conductors of heat, and are not attacked by weak acids or alkalies. They are serviceable far subterranean telegraph lines, speaking-tubes, and gas mains. Asphalt pavements, roofing paper, and artificial stone are too well known to require detailed notice.

The crude oils resulting from the distillation of schist, boghead, and petroleum, when treated with sulphuric acid, separate a tarry mass which has hitherto been a waste product. F. Blaudin, of Metz, has sold to the Italian Government a process for working up this "sludge," as it is called, to advantage. It consists in treating the sludge with a concentrated solution of common salt, when the sulphuric acid separates as sodic sulphate. Ammonia chloride may also be employed, by which means ammonic sulphate may be obtained. On washing the tar with much water and a little alkali to neutralise what acid there may remain, a very good tar is obtained, lighter than ordinary tar, and suitable for various purposes.

The value of coal ashes as a manure is very considerable; but they can only be obtained in quantity in the neighbourhood of large manufactories. They contain lime and magnesia, the chief ingredients being siliceous and aluminous earths, which vary much in their nature and proportions; also some iron, much carbonic-acid gas, and carbon and hydrogen. The ashes require to be bruised into powder by mallets, and spread on grass-lands as a top-dressing in March and April, at the average rate

of 60 bushels to the acre, in moist weather, when the good effects are very great and generally certain. The use of coal ashes and of all alkaline matters is always recommended on sour pasture which produces sorrels, rushes, and mosses, in order to banish those plants by depriving the land of the peculiar properties necessary for their growth.

The ashes of soot are various. It is a clammy, earthy, volatile matter arising with the smoke by the action of fire or combustible bodies, and condensed on the sides of the chimneys. Though once volatile, it cannot be again resolved into vapour. It has escaped perfect combustion from insufficient contact with air, and may be burned again; the black and brownish colour arises from an oil that is burnt and half reduced to a state of coal. The soot produced by the combustion of coals is usually reckoned better in quality than from wood or peat: and soot from kitchen chimneys, impregnated with the effluvia of cooked victuals, is thought to be better than from other chimneys. But experience does not sanction any difference in that way. Soot can only be obtained in quantity in the vicinity of large towns, and the chimney-sweepers sell it at about 6*d.* per bushel.

A pigment known as bistre is made from soot, and some colour-makers prepare from it a pale-red solid paint. M. Braconnat, of Nancy, by the aid of soot dissolved in water, has preserved animal substances for several months without alteration, and given them the flavour of smoked meats. It is also used for tempering objects of iron, to which a steel surface has to be given. But the presence of a notable quantity of sulphate of ammonia in lampblack shows that it ought not to be employed in the reduction of metals, when the object is to obtain them pure, and not in the condition of sulphurets.

Soot is a very powerful manure, and surpasses all other substances in giving a healthy hue to young plants of grain, clovers, grasses, and legumes. On the pastures the effects of soot are great, and if it is spread by hand over the surface in the autumn or spring, in the proportion of 40 bushels to the acre, the quantity of herbage is much increased, and the quality of the grass invites the grazing animals beyond any other. The effects last, however, only

for one year. The volatile properties soon vanish, and the earthy base is very easily soluble,

The beneficial effects of a topdressing of soot are wholly attributable to the sulphate of ammonia it contains; the quantity being on an average about one-tenth of that obtained from an equal weight of common sulphate of ammonia, which would make it worth about eightpence per cwt. Great quantities used to be sent to the West Indies, particularly to Barbados. This article is much adulterated. Recently it has been stated that potash has been found in appreciable quantities in the soot from iron furnaces; not sufficient, however, I believe, to make its extraction profitable.

Among the essential products of soot from wood are sulphuric and phosphoric acids, which appear to result from the combustion of sulphur and phosphorus contained in the wood. Soot may be employed for the purpose of obtaining a deep brown colour of various shades for paper-hangings, by simply diluting with water a mixture of soot in powder and slaked lime.

Lamp-black is a kind of soot, the carbonization of which is much more advanced than that of common soot. A few years ago, a party of gentlemen started what they intended to be an oil-well, near Cumberland, Maryland. They soon, however, were disappointed in their expectation, for instead of striking oil, they came upon a gas-chamber. A short time afterwards the emitting gas was accidentally set on fire, and continued to burn for a period of two years. About a year ago Mr. Haworth, a gentleman from Boston, having heard of the burning well, went to Cumberland, tested the quality of the gas, and was satisfied that he could put into operation a scheme or plan of his own for the manufacture of carbon (lamp-black) from the gas. Accordingly, the well was leased or purchased, and a patent obtained for the manufacture, according to the plan of Mr. Haworth. A building was constructed, and the manufacture commenced.

There are now in operation six hundred and sixty burners, each burner consuming eight cubic feet per hour. The gas is allowed to burn against soapstone plates, on which the carbon is deposited in the form of soot. By a very neat mechanical arrangement, the soot is scraped off

and deposited in large tin boxes about three feet long, a foot and a half wide, and a foot and a half deep; scrapers are passed along the soapstone plates every twenty minutes, and the boxes are filled on their fourth passage. A large building is now in course of construction, twice the size of the present one, which will have in use thirteen hundred and twenty-eight feet gas burners. The present consumption of gas amounts to about one-twelfth of the whole quantity escaping from the well. When the new building is completed and the burners put in operation, the total consumption of gas, by the burners of both buildings, will be one-fourth of the whole.

The carbon is used for the manufacture of ink, and these works I believe are the only ones of the kind in America; and as far as the knowledge of the owners extends, the only ones of the kind in the world.

There is another substance approximating to coal, though possessing the general properties of bituminous schists, shale, or clay, which can scarcely be passed over here: the Torbane Hill mineral, which has become world-wide in reputation. It lay unheeded until about 1850, when it came to be extensively worked for the superior gas and oil obtained from it.

The following is an abridged table of analyses of Scotch cannel coals, and of the Torbane Hill mineral, made by Professor Anderson, of Glasgow:—

	Coal.			Whole Residue.	Percentage composition of residue.	
	Volatile matter.	Fixed carbon.	Ash.		Carbon.	Ash.
West Wemyss	51·96	35·35	12·69	48·04	73·6	26·4
Capeldrae	54·26	38·57	7·17	45·74	84·4	15·6
Leshmahagow (Duke of Hamilton's)	54·09	42·51	3·40	45 91	92·6	7·4
Leshmahagow (Mr. Ferguson's)	49·10	43·71	7·19	50·90	85·9	14·1
Arniston	58·34	39·67	1·99	41·66	95·3	4·7
Torbane Hill—top	56·84	10·86	32·30	43·16	25·2	74·8
middle	73·01	6·67	20·33	26·99	24·8	75·2
bottom	57·00	4·37	38·54	42·91	10·2	89·8

These analyses fully bear out the late Hugh Miller's description of this substance, when he compared it to a lump of clay dipped in tar (or crude oil).

A substance so rich in bituminous and volatile matters did not long escape the notice of the gas companies. In the experiments made by Dr. Fyfe, of Aberdeen, he found that while Newcastle coal gave 9833 cubic feet of gas per ton of coal, Wigan 10,851, this mineral gave 13,334 cubic feet of a gas richer, besides, in quality; and of this five feet are equal to thirty-eight candles. So rich, indeed, has it been found, that it can be consumed with difficulty in burners of ordinary description. In this country it has been principally used, in consequence of its excessive richness, in conjunction with inferior coals and cannels, yielding gas far less rich. But the abundance of gas produced from a material so small in bulk has rendered it invaluable for purposes of exportation. The great value of this mineral as an oil-yielding substance was at once appreciated by one who lost no time in proceeding to action. Mr. James Young patented the making of paraffin oil from bituminous coals. Contemporaneously with the introduction of the mineral into the market in 1850, extensive chemical works were established at Bathgate by Mr. Young, in partnership with Mr. Binney and Mr. Meldrum, for the manufacture of the various substances included under the patent, as yielded by the mineral in question. The manufacture includes two varieties of what is termed paraffin oil; the first a highly valuable, because most economic illuminating oil, preferred by many as a most efficient substitute for coal gas, particularly in country districts; and the second a thicker oil, extensively used for lubricating purposes. The chemical works produce likewise various cognate chemical manufactures. These works have gone on increasing year by year, and now absorb a considerable portion of the Torbane Hill mineral.

In Scotland there are now sixty-eight oil-works, which together consume about 782,000 tons of shale annually, and produce nearly twenty-two million gallons of crude oil, yielding, in round numbers, ten million gallons of burning oil, 5000 tons of paraffin, and as a by-product about 600 tons of sulphate of ammonia.

Many Scotch gas companies have been using shale lately. Inconvenience is experienced from the large refuse heaps of useless materials. Should parrot coal altogether disappear from the market, excellent gas can be made from

shale, but a marketable article has not yet been made from the shale refuse, which still baffles the ingenuity of paraffin manufacturers.

When the distillation of petroleum is carried to the full extent, there is left a residue of compact coke. As an article of merchandise, this coke is at present valueless; but many refiners use it as fuel, for which purpose it is tolerably well adapted.

Paraffin and its Uses.—Professor Joy, in the American 'Journal of Applied Chemistry,' thus writes: In 1830 Baron von Reichenbach (who died in 1869) discovered a white waxy substance in the products of the distillation of wood, to which, owing to its permanent character and chemically indifferent properties, he gave the name paraffin. from *parum affinis.* Since that time it has been observed that it is produced during the distillation of many organic substances, such as resins, bituminous coal, lignite, brown coal, peat, fats, wax, bituminous shales, Boghead coal, and that it occurs ready formed in petroleum, in the mineral ozokerit, in bitumen, and earthwax.

From being an article of insignificant chemical importance, it has risen to the front rank of valuable technical products. I distinctly recollect seeing in a small case at the Paris Exhibition of 1855, a few candles and a white block resembling spermaceti, on which was inscribed the word "paraffin." Not one in ten thousand of the passers-by had the remotest knowledge of what it was. In the Paris Exhibition of 1867, this article made its appearance everywhere, and I daresay there were tons of it in the building. The applications of paraffin are now so numerous and important that it is difficult to trace them through all their ramifications. The best source for the literature on the subject is Wagner's 'Annual Reports on Technology,' and of that I shall make free use. The methods for the manufacture of paraffin are different, according to whether it is a direct or an incidental product. I shall mention some of the most important processes actually pursued in the arts. That paraffin was contained in petroleum was known as early as 1820, and Buchner, who found it at that time in the Bavarian oil, is sometimes called its discoverer.

The idea of employing petroleum as a source for paraffin was not fully cultivated until 1856, when the market

became supplied with an oil unusually rich in this material. American petroleum contains very little, but the Indian, and especially Rangoon and Java oil, affords from 10 to 40 per cent. The crude petroleum is distilled until 25 per cent. has gone over; the remaining portion is subjected to a higher temperature, and toward the last the paraffin goes over, which is condensed by surrounding the tanks with ice or artificial mixtures for the production of cold.

Ozokerit was first discovered as a mineral species in 1833, in Moldavia, by Von Meyer, and is known throughout the German countries quite familiarly as *Erdwachs* (earthwax). Even its occurrence in the Caspian region is by no means a novel announcement. Quenstedt, in his 'Mineralogie,' p. 648, under *Ozokerit*, speaks of it from the island Tschiliken in the Caspian. Its composition approaches carbon 85, hydrogen 15, which appears to indicate that it belongs to the saturated hydro-carbons, as the most eminent of living chemists, Berthelot, appears to have proved. It must be remarked that Berthelot's examination of American paraffins by his method of synthesis by hydrogenation, gave him a molecule much more highly condensed than this, namely—C^{80} H^{14}, calling for the centesimal composition—carbon 85·04, hydrogen 14·96. An analysis of Galician ozokerit, by Hofstaedter, is cited by Dana, in his last edition (p. 732), which gave—carbon 84·94, hydrogen 14·87. All paraffins, however, both natural and artificial, are evidently mixtures of compounds of typical composition, which may vary within small centesimal limits.

In the factory of Messrs. Field, where candles are made from it, ozokerit is found in two conditions, as dug from the earth, and as roughly melted down for the convenience of storage in transit. In the latter condition it forms a dark-coloured mass, and is packed in barrels; the native or unmelted ozokerit being sent over in canvas bags. From the stores the crude material is conveyed into melting-tanks, holding from two to three tons each, and where it is melted down by means of a steam coil. From these tanks, which are situated in a gallery some fifteen feet above the ground-level, the ozokerit is run off by gravitation to a series of stills placed outside the main

building, and in which it is distilled over, partly by steam and partly by bottom heat. The dirt and sediments from the crude ozokerit are run off from the melting tanks into another set of tanks beneath them, where they are re-melted, the finer products being afterwards distilled over. The ozokerit comes over from the stills in the form of an oily distillate, which is run from the condensers into moulds, and allowed to cool. This gives a deep yellowish wax-like substance of a spongy nature, the pores being filled with oil, which exudes under a slight pressure. These cakes are packed between oil-skins and canvas cloths, and placed in hydraulic presses, of which there are three of large capacity. The pressed cake after removal is put into re-heating tanks and again melted down, and is pumped from these tanks by a steam pump into the acidifiers, where it is treated with sulphuric acid. These acidifiers are steam-jacketed, and are fitted with revolving agitators, by which the ozokerit and acid are agitated for a certain time, after which the mixture is allowed to settle. After settling, the purified ozokerit is drawn off from the lower part of the acidifiers—the acid remaining on the top—and run into vessels which are heated by bottom heat. This is the final heating, and from these vessels the fine stuff is drawn off into moulds, the result being a hard, white wax, the melting point of which is 140°, that of paraffin wax being only 128°. These blocks are sent to Messrs. Field's works at Lambeth, and from them the now well-known ozokerit candles are made. In some cases, and under certain conditions which occasionally present themselves in the process of manufacture, the ozokerit when separated from acid is washed with hot water. The water having been removed, the material is repeatedly filtered through animal charcoal, until the requisite degree of whiteness is obtained. There are also several specialities about the manufacture which require to be conducted with the greatest nicety and exactness, or the looked-for results may be entirely negatived. One point is that of temperature, those attained in the stills being exceedingly high and variable, with certain varying circumstances, and at different stages of the process. Another point is the length of time during which the ozokerit is exposed to the action of the acid or of the charcoal. It is also important

whether and when, either the acid bath or the charcoal filter should be used. There are several by-products, the chief of which is a very clear colourless oil, without smell, and of very high illuminating power.

A substance called ceresine, obtained as a by-product in purifying ozokerit for the manufacture of paraffin, is now used in Vienna as a substitute for beeswax in certain medicinal preparations.

Latterly the manufacture from ozokerit has been conducted on an immense scale. The introduction of this name into commerce affords a striking illustration of successful advertising. It is said that the originators of the manufacture spent twenty thousand pounds sterling in posting the word on to every available dead wall, conspicuous rock, or high fence, and in advertising it in every language and every country, until the curiosity of the whole world was raised to a high pitch in anticipation of the coming wonder. After waiting a few years, public curiosity was gratified by the appearance on the market of some remarkably fine candles, which, on inspection, proved to be the well-known paraffin. The capital invested in the new enterprise is very large, and the production of pure paraffin somewhat startling. Ozokerit, as it is found in Austria, Moldavia, the Caucasus, and near the Caspian Sea, is a vegetable wax of a yellowish colour, fibrous structure, and light specific gravity. In its natural state it will melt readily, but requires to be wrapped around a wick before it will burn. About 300 pounds of the crude material are subjected at a time to fractional distillation in an iron still, provided with coolers and condensers. The yield is 8 per cent. oil and 60 per cent. paraffin. The oil is reserved for illuminating purposes. A small portion of the light oil, which boils before 212° F., is subsequently used in refining the paraffin. The crude paraffin contains an oil which is removed under a hydraulic press, and distilled to save adhering paraffin, and for other purposes. The press cakes are melted and treated with sulphuric acid. The acid is neutralised with lime, and the paraffin distilled off. The product is again pressed, melted with the light oil mentioned above, and once more pressed. The final result is a perfectly white, transparent, hard substance, quite pure, and inodorous, having a metallic ring, and fusing at 63° C. (113° F.) Its

chief use is in the manufacture of candles. The manufacture of paraffin by the dry distillation of peat and Boghead coal is divided into two operations: 1. The production of tar. 2. The working up of the tar for illuminating oil and paraffin. Before the discovery of petroleum, this industry was regarded as one of great importance, and it was anticipated that most of our burning oil would come from this source. The trade name of the oil was *kerosene*, a word which has since been applied to refined petroleum. After the introduction of petroleum, the Boghead industry declined in the United States, but it is still important in Scotland, where great quantities of paraffin are yearly made according to Mr. Young's patent. Mr. Young originally subjected the Boghead coal to a downward distillation, but numerous modifications have been introduced, according to the nature of the crude material. More attention has latterly been bestowed upon the coolers and condensers than formerly. The methods of compressed air, ether engines, and condensation of ammonia, have been applied to the cooling of paraffin on a large scale, and the yield has thus been appreciably increased.

It is in this method of artificial refrigeration that the chief progress has been latterly made. Paraffin, in its pure condition, is a white, waxy, inodorous, tasteless substance, harder than tallow, softer than wax, with a specific gravity of 0·877. Its melting point is variable, depending somewhat upon its origin. It ranges between 43° C. and 65° C. (109° F. and 151° F.) An ultimate analysis yields, on the average, carbon 85 per cent. and hydrogen 15 per cent. It is insoluble in water, is indifferent to the most powerful acids, alkalies, and chlorine, and can be distilled unchanged with strong oil of vitriol. Warm alcohol, ether, oil of turpentine, olive oil, benzole, chloroform, and bisulphide of carbon dissolve it readily. It can be mixed in all proportions with wax, stearin, palmatine, and resin. As stearin is less soluble in benzole than paraffin, Vogel proposes this reaction as a method for detecting the adulteration of paraffin with stearin. Further properties can be inferred from the uses to which it is applied. It burns with a wick, and gives much more light than stearin or wax, but as it melts at a low temperature, it cannot be advantageously employed alone. When required for

eandles, it is melted with stearin wax and spermaceti, to render it less liable to bend over in warm weather, or to run. There arė single establishments in Germany capable of turning out 250,000 eandles daily, and in England even these figures are exceeded. As the melting point of paraffin is low, it has been proposed to employ it for the preservation of meat. Meat several times immersed in a bath of melted paraffin will keep for a long time, and when wanted, it is only neeessary to melt off the adhering wax-like coating to prepare for eooking. For stoppers to acid-bottles, to coat paper for photographic and other uses, as a lubrieator, for eandles, as burning oil, to coat pills, in the refining of alcohol and spirits, paraffin now finds ready use. It has also been employed for the adulteration of chocolate and candies; for the preservation of railroad timber; to saturate filtering paper for certain purposes; to eoat the sides of vessels in which hydrofluoric acid is to be kept; to preserve fruit from decay; for oil baths of constant temperature; to prevent the oxidation of the protoxides; to render fabrics waterproof; as a substitute for wax in the manufacture of matches; as a disinfecting agent, and as a varnish for leather. Franz Stolba, of Prague, suggests the use of paraffin as a eoating to vessels of glass or porcelain when these are acted upon by certain liquids to be set aside for crystallisation. The paraffin is put into the capsules, previously well dried and heated, till it commences to boil; the vessels are then turned about so as to bring the paraffin in eontaet with the whole of the interior surfaee, and the surplus is then emptied out. After cooling, it is found to hold well, and the vessels are ready for use. Of eourse the solutions to be erystallised must not be heated, but left to spontaneous vacuum evaporation. Wine and beer casks are rendered tight by paraffin, and its introduction into the vacuum pans of the sugar industry is said to prevent frothing of the syrup. Plaster casts are coated with it; drawing paper is rendered transparent; parlour matches are tipped with it; sponges are kept elastie; eloth is rendered water-tight, and is employed to keep shoemakers' wax soft and pliable. A paraffin insulator is in use upon some of our telegraph lines, and as there are few substances that can attack or deeompose paraffin, its value in many chemieal processes is

obvious. One of the most recent uses is in the manufacture of sulphuretted hydrogen gas. If sulphur and paraffin be boiled together in a flask, decomposition takes place, and a copious supply of sulphuretted hydrogen is given off. I have found this to be one of the most convenient methods for the preparation of this gas for class-room experiments. In medicine, the preservative and protective properties of paraffin are brought into frequent requisition, and in candles it also plays a part. Such are some of the leading features in the manufacture and uses of paraffin.

Trinidad Pitch.—There is another waste substance which is beginning to be utilised. I allude to the abundant supplies from the semi-solid pitch lake of Trinidad, which covers about a hundred acres. Considering the uses to which cheap asphalte might be applied in road-making as a substitute for stone, as a roofing material, as fuel, as an oil-producer, and as a colour-maker; and considering, too, that the so-called waste on purification is capable of being utilised and turned to profitable account—it is matter of surprise that energy and capital have not yet been found to undertake systematically the utilisation of this pitch lake. Within the last few years, commercial attention has been more prominently drawn to this article. In the report of the North American Commissioners, appointed to inquire into the commerce of the West Indian Islands, Central and South America, submitted to the Governor-General of Canada, in 1866, it was stated that two companies, one English and the other American, had been established to work this pitch lake, and to ship the product, in blocks of asphalte, or refined as petroleum oil, and this article bids fair to become one of the most important staples of commerce in the island. The distillation of oil has, however, been given up, merely owing to the insalubrity of the locality. One of the companies had contracted to supply a French firm with 1500 tons of the pitch per annum, in the form of asphalte blocks, for paving, at nine dollars a ton free on board; and also to furnish a firm at Antwerp with 20,000 tons yearly, at 50*s.* a ton, to distil for oil. The pitch or asphalte is, however, rather an objectionable cargo with shipmasters and insurers, from its dead weight, &c. While in charge of the Trinidad products at the Paris Exhibition, I had many inquiries as to the prices of this asphalte.

The bitumen from Trinidad, Cuba, California, Nicaragua, Peru, and Canada has been proposed as a source for paraffin. That from Trinidad yields nearly 2 per cent.

Though the surface of the Trinidad pitch lake is generally too firm to receive a foot-print—just hard enough to cut readily with an axe—there are places where the pitch oozes out in nearly a liquid form. But the pitch is not confined to this locality. There are masses of it extending wider inland, and in several points it reaches to the sea-beach, where it is shipped in large quantities to America, and some of the other islands, to use in building and flagging streets. Near the lake some of the negroes occupy themselves in boiling down the pitch, some of which is shipped in a pure state, and some, with the addition of lime, exported as mastic. Many hundreds of tons have been thus taken from the lake, to the depth of about a foot below the surface. The hole is always filled again within two days after the cutting, by the upheaving of the mass. It appears as though billions of tons of pitch had boiled up from the bowels of the earth, from the effects of an immense subterranean fire, which had been extinguished, and left the asphaltum to cool in enormous bubbles.

Various attempts have been made to apply the inexhaustible store of bitumen afforded by this lake to some useful purpose. It is the best substitute for macadamisation yet discovered. Mixed with sand and pebbles it is much used for pavements and the ground floors of houses at the town of Port-au-Spain, a purpose for which it is admirably adapted. The late Sir Ralph Woodford, when governor of the island, tried to obtain carburetted hydrogen gas from it to light a beacon on the tower of Trinity Church. It burnt well, but created such an intolerable stench, that the experiment was obliged to be abandoned. The person entrusted with the trial, however, knew nothing of chemistry. It has been employed to advantage as fuel by the American steamers plying on the Orinoco. It is thrown into the furnace among the wood, fusing too readily to be used alone.

With 10 per cent. of resin oil it forms an excellent pitch for vessels. It was used for this purpose so far back as 1593 by Sir Walter Raleigh, who tells us that this substance

was in general use by the various tribes of Indians in the river Orinoco for caulking their canoes. It might, I should suppose, form a base for some of the compressed artificial fuels.

Bitumen consists approximately of—

Carbon	85
Hydrogen	12
Oxygen	3
	100

The amount of available bitumen at Trinidad is estimated at about 134,358,000 cubic mètres in volume, or forty-seven millions of tons by weight. It is solid up to the temperature of 20° to 25°, with a density of 1·3°. A mixture of equal quantities of this bitumen with Newcastle coal will, according to Drs. Letheby and Keates, give for every ton 10,600 feet of gas of 17·6 candles illuminating power. According to Dr. Anderson the amount will be only 10·080 feet, at 16·5 illuminating power. Mr. H. P. Stephenson states that—

	Cubic ft. of gas.		Candle power.
20% Boghead with 80% Newcastle gives	10,040	..	18·7
20% Wigan „ 80% „ „	9,440	..	14·9

As above, according to Dr. Letheby and Mr. Keates—

50% Trinidad with 50% Newcastle gives	10,600	..	17·6

And according to Dr. Anderson—

50% Trinidad with 5% Newcastle gives	10,080	..	16·5

It is inferred that the Trinidad bitumen is superior to the compact Wigan by one half.

Professor J. S. Newberry, in some notes on American asphaltum in the 'American Chemist,' remarks:—"All my observations on asphaltes have resulted in the conviction that, without exception, they are more or less perfectly solidified residual products of the spontaneous evaporation of petroleum. In many instances, the process of the formation of asphalte may be witnessed as it takes place in nature; and in our oil-stills we are constantly producing varieties of asphalte. These are, in some instances, undistinguishable from the natural ones, and in general differ from them only because our rapid artificial distillation at a high temperature differs from the similar, but far slower,

distillation that takes place spontaneously at a low temperature. Asphaltum occurs in America, as does petroleum, in an immense number of places—so many that I cannot enumerate even one-half of those known to me. I will, however, notice a few of the most interesting. The asphalte from these various localities exhibits great diversity of physical character, and some of chemical composition. These differences are doubtless, in part, due to differences in the petroleums from which they have been derived. The greatest noticeable diversity is, however, probably due to difference of age, and is a record of the slow but constant changes which time effects in these as in other organic compounds. Among the most important of our asphaltic minerals are the Albertite and Grahamite; the first from New Brunswick, the second from West Virginia. Both these are found filling fissures, opened across their bedding, in strata of the carboniferous age. The geology of the districts where these deposits occur has been described by Professors Dawson and Lesley, and it is unnecessary now to repeat the details which they have given. Suffice it to say that the fissures filled by both the Albertite and Grahamite mark lines of disturbance, where the strata are more or less tilted and broken, and where oil-springs abound. There is little room for doubt that in each instance the fissures which contain the asphalte have afforded convenient reservoirs into which petroleum has flowed, and from which all the lighter parts have been removed by evaporation. A large number of similar deposits, though of less magnitude, are known to me, all presenting the same general features. Among these I may mention a nearly vertical bed in the mountains west of Denver, in Colorado. This is a fissure filled with an asphalte which I submitted to Professor Henry Wurtz for examination, and which he has shown to be not essentially different from Grahamite. On the banks of the Arkansas, south from Denver City, a number of smaller fissures, cutting cretaceous rocks, are filled with a similar asphaltic mineral. In the great Devonian black shale of Ohio and Kentucky (Huron shale), fissures cutting across the bedding of the formation, filled with Albertite, occur near Avon Point, Lorain Co., Ohio, and Liberty, Casey Co., Kentucky. Petroleum flows from this formation nearly

everywhere along its line of outcrop. The asphalte from all the localities I have cited is hard, bright, and brittle, and seems to be the product of very long-continued and complete spontaneous distillation and oxidation. In Southern California, Western Canada, Central Kentucky, and Chicago, &c., an asphaltum may be seen in the process of formation from petroleum. In Enniskillen, Canada, an abundant flow of dark and heavy oil has produced large accumulations of more or less perfectly-formed asphalte at the surface. These are locally known as gum-beds. They attracted the attention of Mr. Williams in 1860, when the distillation of oil from cannel coal, bituminous shales, &c., was expanding into an important industry, and he established an oil distillery there for the use of this material. On cutting through the crust of solidified asphalte, semi-fluid, and, finally, fluid petroleum was met with; afterwards these oil springs yielded immense quantities of petroleum. In Butler Co., Kentucky, the central member of the lower carboniferous group is saturated with petroleum. This flows out from the cut edges of the formation in the valley of Green River and its branches, forming sheets of mineral tar, and ultimately asphaltum, which cover the exposed surfaces of the rock. The quantity of asphaltic material in this vicinity is large, and it may some time be utilised for road-making in the same manner as the Seyssel asphalte. In Southern California, the accumulations of asphalte on the coast of Santa Barbara, San Luis, Obispo, &c., have attracted the notice of all travellers who have visited that region. The asphalte is here plainly inspissated petroleum. It drips from the cliffs at many points, and forms a scum on the ocean off the coast. There it is evaporated and oxidised, then thrown upon the beach by the waves, where it accumulates in large masses, generally mingled with sand and other foreign matter. When pure, the asphalte of California resembles that from Trinidad, and is beginning to be used for the same purposes—roofing, paving, lining of cisterns, &c. The wants of the entire western coast can be easily supplied from this source. About Chicago, Illinois, the Niagara limestone is in some localities completely saturated with a thick petroleum, which on exposure is converted by evaporation into asphalte. There are no important asphaltic accu-

mulations here, and it is a little doubtful whether the hydrocarbon which fills the limestone is not too oily to serve the same purpose as the bitumen in the limestone of Val de Travers. But I know of no asphaltic limestone which approaches nearer to the foreign variety now so largely used, and it is quite possible that with appropriate treatment others may be utilised in the same way. The above list includes all the important deposits of asphaltum in our country of which anything definite is known. At various points in the Far West occur what are known as 'tar springs,' really oil springs, around which more or less asphaltum accumulates as the result of evaporation. In Texas, south from Shreveport, a pitch lake is spoken of, in which are said to occur large quantities of bitumen. But of this almost nothing is known. In anticipation of a great demand for asphaltum for the uses to which it is so extensively applied in Europe, I have endeavoured to ascertain the quality and quantity of all the asphaltic materials found in our country, and with the exception of the Albert mine, have visited all of the localities described in the above notes. The result of my observations has been the conviction that, aside from the Albertite and Grahamite, which, from their peculiar character, will but partially supply our want of asphaltic material, we must look to Trinidad as a source from which we are to obtain the greater part of our asphalte. The quantity existing there is inexhaustible. The quality is such that it will, with proper treatment, do all that asphalte will anywhere do, and it is so accessible, and transportation to our seaports so inexpensive, that it should be furnished from this source to our Atlantic cities at a much less price than asphalte brought from any point in the interior must cost."

There is a small lake or pond of bitumen or asphaltum, about a quarter of a mile in circumference, in Jefferson Co., Texas, between Liberty and Beaumont, and about twenty miles from the latter village.

Bitumen to the value of £30,960 was shipped from Beyrout, Syria, in 1871.

The imports of this waste substance into the United Kingdom have been yearly increasing, owing to the large demand for varnish, for paving, and other purposes; but it

is principally the cheaper kinds that are coming in from the Continent, Trinidad, &c.

	Tons.	Value.
1867	2,442 ..	£33,634
1868	2,361 ..	28,524
1869	4,257 ..	82,911
1870	6,151 ..	124,473
1871	14,430 ..	52,485

Some few years ago the Egyptian or Turkish asphalte fetched as much as £75 the ton, but it has since gone down in price. In 1872 there were 9000 tons of raw asphalte shipped from Trinidad, and 4490 tons of boiled; in all 13,490 tons valued at £16,767.

Utilisation of the Soda-Waste.—It is a well-known fact that more than nine-tenths of the sulphur used in the manufacture of soda is retained in the material called "alkali-waste," which is thrown away by the manufacturer. Thus is presented a problem, the thorough solving of which would effect a large reduction in the cost of soda. Many chemists, both scientific and practical, have given a great amount of attention to this subject. The soda manufacture is estimated at upwards of two millions sterling in value, and as the main cost of production is some £5 per ton for sulphur from pyrites, any reduction on this must therefore be an enormous gain to the manufacturer.

Numerous plans have been proposed for the utilisation of the residuum of Leblanc's process, which accumulates round the larger alkali works in enormous quantities, in some cases at the rate of five or six hundred tons per week. From 15 to 20 per cent. of sulphur lies buried in it—a total loss to industry, and a positive detriment to the surrounding air, which it infects with the noisome odour of sulphuretted hydrogen. Its very bulk, however, coupled with the small value of any product likely to be derived from it, renders its manipulation very unpromising, and accounts for the indifferent success that has generally attended on the plans suggested for turning it to account.

M. Delamare proposes to boil the alkali-waste with sulphur, and to use the polysulphide of calcium thus produced for medicinal purposes; also for making sulphuretted waters, for precipitating cobalt and nickel, for sulphurising

the vine, &c. Mr. Deacon, of Widnes, utilises the alkali-waste for making floors; M. Varrentrapp suggests its employment for building chimneys, walls, &c.; M. Vuhlmann mixes it with the impure peroxide of iron, constituting the residue of burnt pyrites, for making bricks, tiles, &c.; Messrs. Townsend and Walker have taken up the suggestion of M. E. Kopp to employ soda-waste for preparing the hyposulphites of calcium, sodium, aluminium, &c. Several processes have been patented with this view by Losh, Noble, and others. Considerable quantities of the hyposulphite of sodium used in photography and as antichlor, are stated to be obtained from this source. An example of the processes proposed with this view, and one of the most feasible, is that adopted by Mr. L. Mond.

He exposes the soda-waste on large hurdles, for eighteen or twenty days, to the oxidising action of the air, and lixiviates the oxidised product. Hyposulphite is thus obtained in solution; and the washed residuum is again exposed on the hurdles for a second oxidation, giving rise to a further supply of hyposulphite. This operation cannot profitably be repeated oftener than twice; but even thus no less than twelve per cent. of sulphur is recovered from the waste. The solution of hyposulphite, boiled to dryness, yields a solid salt which, on distillation alone, yields half its sulphur in the form of sulphurous acid. If it be distilled with the addition of hydrochloric acid, the whole of the sulphur is recovered as sulphur and sulphurous acid.

Messrs. Townsend and Walker also turn soda-waste to account by mixing it with the residuum of the preparation of chlorine. When the mixture contains an excess of the latter residue, a precipitate of sulphur is obtained. A mixture containing less of the manganesic residuum yields a mixed precipitate of sulphur and proto-sulphide of iron, leaving in solution very pure chloride of manganese, fit for the preparation of regenerated peroxide. Lastly, the two residues, mixed in such proportions as to insure complete double decomposition, give rise to a solution of chloride of calcium, and to a mixed precipitate of sulphurous proto-sulphide of iron and sulphide of manganese, capable of yielding sulphurous acid by roasting.

Messrs. Favre and Spencer, as well as other chemists,

have proposed to decompose the alkali-waste by weak hydrochloric acid, so as to evolve the sulphur in the form of sulphuretted hydrogen. To utilise this product Mr. Favre either burns it in the lead chamber, or brings it in contact with moist sulphurous acid, so as to obtain a precipitate of sulphur. Mr. Spencer absorbs the sulphuretted hydrogen by sesquioxide of iron, and exposes the product to the air, so that the sulphide of iron may be oxidised, and thus reproduce sesquioxide of iron together with free sulphur. He continues this treatment till the sulphur has accumulated in sufficient quantity, and then burns the mixture to supply sulphurous acid to the leaden chambers.

Although some of these processes are useful and practicable, they can be applied only to small quantities of the alkali-waste, and the great bulk still remains useless. The great desideratum is either to find a process in which this residue shall not be found, or an application which shall allow it to be used just as it is, without the necessity of submitting it to chemical manipulations. With reference to this latter alternative, Mr. P. Ward ('Essay on Artificial Manures') observes that soda waste, oxidised by exposure to the air or by spontaneous combustion, becomes converted into a valuable manure. Its spontaneous combustion may be effected, he says, by piling it, fresh from the works, in a loose high heap; when it soon heats, takes fire spontaneously, and burns with a pale blue flame, emitting sulphurous and carbonic acids. The product mixed with earth is stated to make a good compost for dressing light sandy land, and to be particularly suited for turnips. For stiff lands and cereal crops Mr. Ward recommends an autumn dressing of unburnt soda-waste, three inches deep, to be left exposed through the winter months and ploughed in before sowing time in spring. A field thus dressed gave, he says, without further manuring, three full average wheat crops in succession, and an oat crop in the fourth year. The oxidation of soda-waste, whether by slow atmospheric action, or by its spontaneous combustion as described, brings about nearly similar changes in its composition. The calcic sulphide becomes converted into gypsum, which acts as an absorbent of atmospheric ammonia. The residuary coke, in virtue of its porosity, Mr. Ward believes to have a similar absorbent

property; while the sodic-chloride and sulphate, the traces of sodic-carbonate, and the silica, &c., are all more or less useful to vegetation. This agricultural application of soda-waste, should its utility be confirmed by further experience, would probably prove the most feasible of the employments hitherto proposed for this cumbrous residuum.*

The residuum of soda and potash works, known by the name of the oxy-sulphuret of calcium, generally supposed to be useless, has been proved, by the experiments of M. Chevandier on the French forests (laid before the French Academy of Sciences), to be the most wonderful substance ever employed for fertilising purposes. It augments the growth of forests over 100 per cent. In the neighbourhood of soda works there are huge piles of it, the accumulation of years. At Marseilles it is thrown into the sea, while there are, throughout the department, vast pine plantations upon which it might be applied with great advantage.

In July, 1861, Mr. H. Noble, of Bristol, applied for a patent for improvements in obtaining products from alkali-waste and gas lime refuse.

After the desulphurisation of the common soda-waste, the residue, consisting essentially of carbonate, sulphate, and sulphite of lime, has been found useful for the construction of dams, &c., and, besides, seems to preserve railroad ties, keeping them at the same time perfectly dry.

The waste treated in Holland for several years has been used for a great many purposes. The new station at Utrecht has been built on the waste, and a number of houses have also been built upon it. A well used for domestic purposes has been sunk through alkali-waste, and the water, though very hard, employed for domestic purposes.

An invention for the recovery of sulphur from the waste was provisionally specified some time since by Mr. B. Jones, of Warrington. He allows hot water to flow over "blue waste," placed in a suitable vessel, and in a few hours he draws off the liquor. He precipitates the sulphur with hydrochloric acid, and then filters and evapo-

* Dr. Hoffman "On Chemical Products and Processes," in Jury Reports of London Exhibition, 1862.

rates to dryness, The precipitate is then treated in a furnace similar to that commonly used for producing sulphur stone. He proposes to condense the sulphuric acid in a water tower, and to collect the sulphur at the bottom.

The Walker Alkali Company has been manufacturing hyposulphate of soda from alkali-waste for the past eight or nine years.

An interesting paper was read by Mr. L. Mond, on the 6th of May, 1869, before the Newcastle Chemical Society, on his plans for the recovery of sulphur from alkali-waste, and he has since published a statement communicated to the River Pollution Commissioners (at their request), on the probable effect of the general adoption in Great Britain of his process from a mercantile point of view, in which he furnishes elaborate and interesting calculations and details, which are too diffuse to be given here, treating as I do only incidentally of the matter in common with other manufacturing residues.

I may, however, quote a few of his facts and arguments.

The total salt cake from which waste is obtained in Great Britain amounts, he says, to 385,000 tons a year ; and about 90 per cent. of the sulphur, or 66,600 tons, remain in the waste ; one-half of this quantity can be recovered by Mr. Mond's process, the other half being converted into sulphate and sulphide of lime.

To this quantity ought to be added the sulphur obtainable from the liquors draining from old alkali-waste heaps. It is at present almost impossible to form a correct opinion of the amount which might be so obtained.

Mr. Mond considers it to be between 4000 and 8000 tons a year, which would raise the whole amount of sulphur recovered from waste in Great Britain to from 40,000 to 44,000 tons a year.

This quantity might be again increased by breaking into the old waste-heaps, and subjecting them to a regular treatment, and the total production thus easily made equal to the consumption in this country of sulphur, in the form of brimstone, which is rather more than 50,000 tons a year. As however, this would involve additional expense, and would not be necessary for the complete suppression of the nuisance arising from the waste, it had better be left out of consideration.

The total amount of acid run to waste in 1866 in Great Britain was equal to 250,000 tons of strong acid, and this quantity has since certainly not diminished, but rather increased.

All manufacturers do not, indeed, suffer such enormous quantities of acid to run to waste, but some still allow all their acid to waste; others a larger or smaller portion of it; while a few, but only a few, use it as completely as can at present be done. But even these few leave in the waste-liquor run from their chlorine stills eighteen to twenty per cent. of their acid in a free state—which would be quite sufficient to recover the sulphur from their waste. Finally, Mr. Mond observes:—"The general introduction of the recovery of sulphur from waste, which disposes of a quantity of muriatic acid in a very profitable way, and would pay to the alkali trade £160,000 a year, or at the rate of £1 4*s.* or £1 6*s.* 8*d.* per ton of strong acid, would thus also be one of the most effectual means of raising the profits derived from bleaching powder and other articles requiring muriatic acid in their manufacture.

Dr. B. H. Paul, in a letter published in the Journal of the Society of Arts, in February 1869, after the reading of one of my papers "On the Utilisation of Waste," and with the object of illustrating the general importance of studying the materials which are the refuse of manufacturing operations, observed: "As the quantity of common salt consumed in the British alkali trade amounts to no less than 400,000 tons a year, and nine-tenths of the sulphur used in the manufacture of soda remains in the waste discharged from the lixiviating vats, the quantity of sulphur which thus becomes locked up, as it were, cannot be far short of 100,000 tons a year. This sulphur is now being recovered, with a very considerable degree of advantage to the alkali manufacturers, and with the further advantage of preventing that pollution of rivers by the slow decomposition of the soda-waste heaps, which has been such a fertile source of nuisance at alkali works. The method adopted, which is very simple and inexpensive, is the invention of Mr. Ludwig Mond. Its adoption is, in a great measure, due to the appreciative insight of the late John Tennent, manager of the St. Rollox Works, near Glasgow, where it has been

worked some time. This method is also being worked at several other places. The recovery of the sulphur is effected to the extent of one-half of the amount in the soda-waste, and at a cost of about £1 per ton. The sulphur thus obtained is very pure, and serves as a substitute for Sicilian sulphur, which has been imported into this country to the extent of 50,000 tons a year, at a cost of over £6 per ton, not for the manufacture of sulphuric acid—which is now almost entirely made from iron pyrites—but for the various other uses for which sulphur is required. If the application of this method of recovering sulphur from soda-waste were carried out to its full extent at the alkali works of this country, they would, therefore, be able to furnish a quantity of sulphur equal to that now imported from Sicily, not only with profit to the manufacturers, but with the advantage of preventing one of the most obnoxious forms of pollution to which the rivers of manufacturing districts are subject, while the product of the operation would itself have a money value amounting to about £300,000 a year. The fact that the recovery of sulphur from alkali-waste has so long been an object unsuccessfully pursued, together with the results now obtained, should afford encouragement for the persevering prosecution of attempts to utilise other kinds of waste or refuse materials which hitherto have either been neglected or have refused to yield whatever they contain of value in such a manner, and at such a cost, as to be worth extraction."

At the meeting of the British Association at Liverpool, a paper was read by Mr. W. Gossage, "On the Lancashire Alkali Trade." After alluding to the passing of the Alkali Act of 1869, rendering it imperative that all manufacturers decomposing common salt, for the production of sulphate of soda, should condense not less than 95 per cent. of the hydrochloric acid gas evolved by such decomposition, he said:—"The most important use for hydrochloric acid obtained by such condensation is the manufacture of hypochlorate of lime, or bleaching powder, the demand for which has taken an extraordinary development since the introduction of straw, esparta grass, and some other substances than rags for the manufacture of paper. At the date of my last paper, the chlorine re-

quired for the manufacture of bleaching powder was obtained by the action of hydrochloric acid on native peroxide of manganese. Recently, Mr. Walter Weldon, of London, after long-continued devotion of time, labour, and money, has succeeded in perfecting a process by which peroxide of manganese is obtained from the chloride of manganese, produced by the action of hydrochloric acid on peroxide of manganese. Mr. Weldon effects this object by causing the chloride of manganese to be decomposed by hydrate of lime, thus producing hydrated protoxide of manganese, which he converts into peroxide of manganese by causing streams of atmospheric air to be forced through the fluid mixture of protoxide and water. When in this state of minute division the protoxide of manganese absorbs oxygen from the atmospheric air, and becomes converted into peroxide. Mr. Weldon has found it essential for successful working that not only a sufficient proportion of lime be used to precipitate the oxide of manganese, but that such an excess be employed as will be sufficient to form a chemical compound with the peroxide of manganese as this is produced, which compound Mr. Weldon designates as manganite of calcium. This process has been successfully carried into practice in the Lancashire district, also in that of Newcastle, and has already been adopted by some of the large manufacturers of bleaching powder in both these localities. In the year 1861, during the negociation of the French treaty of commerce, it was estimated that the total quantity of salt decomposed in Great Britain for the production of soda was 260,000 tons per annum. Of this quantity 125,000 tons were decomposed in what is called the Newcastle district, and 135,000 tons in the Lancashire district. According to the returns of the Alkali Manufacturers' Association for the year 1869, the total quantity of salt decomposed for the manufacture of soda was 326,000 tons, thus showing an increase of 66,000 tons, or 25 per cent. on the total. Of this quantity the decomposition in the Newcastle district in 1869 was 142,000 tons, which being compared with 125,000 tons in 1861, shows an increase of 17,000 tons, or 13·6 per cent. The decomposition in the Lancashire district was returned at 184,000 tons in 1869 against 135,000 tons in 1861, show-an increase of 49,000 tons, or 36 per cent. It would thus

appear that the total quantity of salt decomposed for the manufacture of soda in the Lancashire district in 1869 exceeded by 31 per cent. the total quantity decomposed in the Newcastle district during the same year." In the ten years previous to 1861 the increase in the amount of salt decomposed was 300 per cent.—that is to say, in the year 1852 there were 38,600 tons, while in 1861 the quantity was 135,000.

In a new process for obtaining sulphur from sulphuretted hydrogen, the sulphuretted hydrogen is caused to react upon oxide of iron, or of manganese, by injection into water holding the metallic oxide in suspension; and atmospheric air is then injected, whereby a mixture of metallic oxide with free sulphur is produced. Into this mixture more sulphuretted hydrogen is sent, and the product is then treated with air as before. These alternate treatments are repeated until the mixture contains a very large proportion of free sulphur, which can be separated in a variety of ways. Soda and potash are manufactured by forming sulphides of sodium or potassium, decomposing these by carbonic acid, and treating the resulting sulphuretted hydrogen as above described. 'Alkali waste' is also decomposed by any suitable acid or by steam, and the resulphuretted hydrogen treated as aforesaid. The invention is also applied to nascent sulphuretted hydrogen.

In the year 1850, Mr. Gossage showed that the copper, amounting to about 1 per cent., in Irish pyrites, could be extracted, and this is still more practicable in the case of Spanish pyrites, which contain about 3 per cent., and, after roasting, from 5 to 6 per cent. The extraction of copper is, however, rarely carried out by the sulphuric acid manufacturer. In England the copper is obtained in the dry way by successive meltings. In France the roasted mineral is exposed to the action of the air, the copper sulphate thus produced is extracted by water, and the metal precipitated by iron. More recently the copper has been extracted as chloride, by melting the roasted mineral with sodium chloride. The method patented by Mr. Henderson is worked at Mostyn with the pyrites residues from Messrs. Muspratt's works, and works have been erected near Glasgow for treating the residues from Messrs. Tennent's works.

The following is the Henderson process for the extraction of copper from the pyrites roasted in the English sulphuric acid works. The ores used are almost exclusively Spanish and Portuguese, and have the following average composition: S. 48·90 per cent., As. 0·47, Fe. 43·25, Cu. 3·10, Zn. 0·35, Pb. 0·93, CaO. 0·20, gangue, 0·73, moisture, 0·70, O and loss, 1·07, besides traces of gold, silver, cobalt, nickel, manganese, antimony, bismuth, and thallium. After the ores have been roasted for the manufacture of sulphuric acid, the burnt ore passes to the copper-extraction works, in order to recover the copper and silver; and the residues from these (the so-called purple ore, or "blue Billy") are, for the most part, sold to the ironworks. In all of the processes it is of the utmost importance to have the ore desulphurised to a certain degree in the first operation, as this greatly promotes all the subsequent ones. The pyrites is broken to pieces in the ore-breakers and sorted into various classes by means of screens; the finer sorts being formed into balls with water and dried on top of the roasting furnaces. The operations consist of—

1. Roasting in kilns.—The sulphurous acid gas escapes from the kilns through a channel into the nitric acid chambers, in which latter Chili saltpetre is decomposed by sulphuric acid.

2. Extraction of the copper.—The desulphurised ore is crushed between rolls, or by some other apparatus, having been previously mixed with 15 to 20 per cent. of salt, and is thus taken to the roasting furnaces. These last consist either of gas reverberatories, muffle reverberatories with fire-box, or furnaces having a rotating hearth with fire-box. Of these three the first is the best, as being the most economical in fuel, and in permitting the use of an inferior quality of coal. Here the ore, mixed with about 17 per cent. of salt, is turned and raked for six to six and a half hours, until it no longer emits any flame and possesses a slight greenish-grey colour. To ascertain the close of the process with certainty, a weighed sample of the product is repeatedly heated with boiling water, afterwards heated with hydrochloric acid to boiling, the liquid poured off, and the residue boiled for one minute with dilute nitric acid.

In consequence of the advanced price of sulphur, pyrites has of late years been largely imported and employed in

the manufacture of sulphuric acid, or oil of vitriol as it is sometimes called. As, on account of the little sulphur left in it, the burnt pyrites is unfitted for manufacture into iron, it was long suffered to accumulate in huge heaps; but now, thanks to the progress of chemistry, about 9600 tons of copper ore are obtained from 350,000 tons of the pyrites. Under the ingenious processes of Claudet and Phillips, carried on at the works of the Lancashire Metal Extracting Company, silver and gold worth 3,700*l.* were extracted in 1871, the sole cost being that of extraction. The expensive element, iodine, employed in the production of silver, is recovered and used over and over again, with little waste, and the loss of zinc is compensated by the lead recovered.

From the washings of the mixture of burnt pyrites and salt, after the silver has been precipitated, copper is obtained, being deposited upon scrap iron of all kinds cast into the solution. The copper is separated from the iron by sieves, and, when washed and drained, is sold to the smelters. Upwards of 9000 tons were smelted in 1871. Formerly the remaining solution of sulphate and chloride of iron, with excess of common salt, was thrown into sewers or canals; but now, from the injurious waste, chemical treatment obtains a sulphate of soda which is used in the manufacture of glass, while the undissolved oxide of iron is sold as rouge of the first quality. Yet, although so many valuable products are obtained from this waste pyrites, much still remains to be done.

The mode of extracting copper from pyrites residues practised in the Tyne district is thus described by Mr. G. Lange. The pyrites, after having been used for the manufacture of sulphuric acid, are washed with the addition of 7½ per cent. or more of salt, the gases from this washing being condensed and used for the lixiviation of the roasted mass, which consists of copper and sodic sulphates, and copper and iron oxide, and the copper reduced out of the solution by the use of iron sponge, as already shown.

In 1870 there were about twenty works in action in the United Kingdom for extracting metal from Spanish and other coppery pyrites, the consumption of burnt ore being 200,000 tons.

About 10 per cent. of the oxide of iron, known as

"purple ore" (which is the residue of the burnt pyrites after the copper is extracted), is used in blast furnaces; the remainder—say 170,000 tons—is employed as fettling ore for the puddling furnaces; it being in a powder, does not require grinding, the same as hematite. The percentage of iron depends on what pyrites it is made from.

The imports of foreign pyrites in 1872 were 516,299 tons, valued at 1,338,640*l.*

The consumption of pyrites in the manufacture of sulphuric acid in Great Britain in the year 1869 was 395,896 tons, three-fourths of which were imported from Portugal, Spain, Norway, Holland, and elsewhere. Of this quantity 265,453 tons were from copper pyrites, which yielded 7600 tons of copper.

Sand and Waste Materials for Casting Metals.—The preparation of moulds in foundries forms an important and difficult part in the casting of metals, requiring much care and judgment in the selection of materials. The substance generally used is sand, sifted fine enough and so pressed as to take the exact imprint of the most delicate objects and the sharpest outlines and contours. Moulding sands, according to Robert Mallet, may be divided into two classes; the first consists of those in which the grains are simply fine fragments of hard materials (quartz or felspar), and which are reduced, washed, and rounded off by nature. To the second class belong those in which each grain represents a small natural crystal.

Although round-grained sand may be a good moulding material, the best kind is undoubtedly the one in which a large portion of the quartz is present in the form of crystals. The best English sand occurs in the oldest formations, the carboniferous group and the Trias; and although good kinds of sand are found in the more recent formations, the English moulder prefers generally the "red sand" from the new red sandstone, to meagre or fat sand of alluvial origin. These are the principal considerations; but it is, moreover, important to know whether the sand possesses the necessary durability, that is, whether it can repeatedly furnish good moulds. It is true that any sand may serve the purpose once; but for the second time, the moulder often is obliged to use it for

refuse casts. Such sand is termed "burned," and it must be replaced by a fresh supply. When freed from clay and carbon, and then compared with fresh sand, under the microscope, we find that the grains of the former are cracked and divided into fine fragments. Originally, such sand generally consists of fragments of crystals with fissures, often filled with iron ochre, or oxide of iron; in other instances it is of a different molecular condition, so that it will decrepitate as soon as it is sufficiently heated. The change constitutes what is called the burning. In selecting moulding sand, therefore, it must be seen that the grains are solid and not broken particles, and that they are not likely to crumble. These conditions are generally fulfilled by the new red sandstone, provided that it has not too long been exposed to the influence of air and water. In castings of great depth, where the liquid metal presses with great force upon the sides, it is often difficult to prevent, upon the surface of the casting, fusion of the rims and the formation of furrows on the sides of the forms. The mixture of iron and fused silicates produced, resists the best cast steel chisels, and the blackening is sometimes torn off in large pieces. In making mouldings for Bessemer steel, which have to resist a higher degree of heat, it is best to prepare a sand or loam from fine clay and quartz. In the steel works at Bochum, Prussia, they cast tyres and wheels for rolling mills of steel, and the manner of making the moulds is still considered a secret. Mallet supposes that the sand used consists of a mixture of fine-grained crystalline quartz sand and of still finer crushed "artificial sand," which is produced by crushing steel-melting pots. It is likely that both materials are bound together with a moderate admixture of wet clay, prepared from the white fireproof clay of the carboniferous group. As regards the coal dust, it may be anthracite or the levigated coal of gas retorts. The blackening seems also to consist of pure fireproof clay and meagre coal. Excellent natural moulding materials are the titanic iron-sands of the western Italian coast (between the Tiber and Naples) and of New Zealand, which are likely to find great use for casting. This is the case with the volcanic tufas, consisting of light refractory dust, which occurs of all colours, but is generally whitish yellow or gray. This

tufa sand is found in all countries and is exceedingly well adapted for casting works of art. For massive castings and bronze, such materials are most valuable. Respecting the parting (isolating) sand, it should be clear, of fine grain, dry and of bright colour, so that, in opening the moulding boxes, the surfaces of the castings may be readily distinguished from the surfaces of the box. For blackening, we use in England mostly coal-dust and soot. Sometimes the sand is mixed with foreign substances, such as molasses and water, beer, yeast, oil, the washing of the starch factories, &c. The addition of coal dust, which is used to the amount of one fifteenth to one-twentieth for green sand, and of one-twentieth to one-tenth for artificial sand, is common. Experience, of course, can be the only guide in selecting the proper proportions. Among the means for regenerating the sand, the following are in use: Ploughing and heaping up in long rows, with furrows of from one to three inches; in this state it is allowed to lie for some time, whereupon it is mixed with fresh coal. I may add a few remarks on the process of blackening. The mould is dusted when green sand is used, and brushed over with black wash when dry sand or loam is employed. With regard to the question in what manner these materials act, it has been shown by Schafhäult that coal, if brought to a white heat, may form graphite. Graphite is formed in blackened moulds, provided that the heat is not sufficient to burn it up; this may be seen in a microscopic examination of the castings. This graphite may act in a twofold manner; first, the crystals lay themselves flat against the sides of the mould and thus prevent the iron from penetrating into the same, or oxide of carbon is formed, which prevents the iron from oxidation. Whether or not cementation (reaction between the blackened mould and the slowly cooling metal) takes place, is difficult to decide, but it is certain that a casting produced without blackening shows a different appearance from that of a well-executed casting, which has a uniform, bluish gray surface with close grain.

The sand used ought at the same time to possess enough consistence and tenacity, so that the sharp angles will not get blunt. To effect this, it is mixed with a certain quantity of clay, so that when it is damp it is possible to

make balls of it. Porousness is given to this mixture by adding coal-dust, so that the steam which forms on contact of the molten metal with the wet sand can easily disengage itself. On the Continent there is a special trade carried on in preparing coal-dust for moulds. M. Mailfert has special works at Chatillon-sur-Seine, where, with appropriate machinery and suitable tools, he is able to turn out from two to three tons of moulding material per day. One tenth of this is exported and the rest used in France. A large number of foundries, however, make their own moulds.

Decomposed sandstone has long been used as moulding sand by iron founders in Lombardy, having been found eminently suitable for the purpose.

Pulverised coke, or mineral black, mixed with moulding sand, forms that which is called by the trade green sand. It is used for moulding small objects of little thickness. This mixture facilitates, by the partial combustion of the coke, the disengagement of the gas upon the contact of the metal with the mould. All kinds of coal-dust are not suitable for making mineral moulds. Some give to the casting a white colour of a bad effect, and to the surface and ends a roughness which cannot be smoothed by filing, and it seems as if the metal had been cool, and had thus become rough. In numerous trials made, great inconvenience was experienced from the use of different sorts of coal; smiths' coal should be employed in small quantities. Broken and sifted, it produces a cleanliness as complete as possible, without altering the surface of the metal, and gives it a very much esteemed bluish tint.

Vegetable blacks are chiefly employed to cover the inside of the mould, and to keep the metal from contact with the wet sand. Vegetable blacks ought not to be inflammable; they should be made of a particular kind of charcoal, prepared in a different manner to the charcoal for forges and that used for fuel in Paris.

The good quality of this article consists in the fact that, when reduced to an impalpable powder, on the spatula being passed over, it ought to give it a very bright surface.

All charcoal cannot be employed in making vegetable

black. It is best to use only that which is called fatty (this quality depends on the mode of making), having a principle of adherence which allows of its being fixed on the mould without getting detached or rough before the trowel.

As already remarked of the charcoal blacks, the mould ought to be covered with a layer isolating the wet sand from the metal.

Vegetable blacks are sufficient for this operation when only small castings are made, but if they are large the black by itself could not resist the heat. It then becomes necessary to employ something offering greater resistance, and a more complete adherence to the sand. This is found in plumbago or stove black.

To use this black it is sufficient to make it liquid by the addition of a little water. The quantity to be employed depends on the degree of fluidity required for the moulds to be coated. A too thick layer is not generally good; it is better to employ the black more liquid, and to give two coatings for massive castings. This black cannot be mixed, its preparation is complete, and the addition of any other matter besides water will be more hurtful than useful. Stove black is especially applicable to cannon founding.

Metallic or Iron Sands.—Besides some of the sands used for glass-making and other purposes, there are many metallic sands which have only very lately been brought into commercial use.

For a number of years past the titanic iron-sand of New Zealand has been the subject of occasional mention, as the prospective foundation of a large metallurgic industry in that colony. But the development of such an industry appears to be slow, for, although it is more than a dozen years since attention was first vigorously called to the subject by the English press, it is still a matter simply of experiment, and not, it appears, of demonstrated practice. Recent trials, however, undertaken under Government sanction, seem to demonstrate the value of the ore for the manufacture of high-class steel, for which its moderate percentage of titanium would seem to especially adapt the material. The process of working is a very simple one. The iron sand, taken directly from the beach, is mixed with an equal quantity of clay and common sand, the

latter composed of silica and minute fragments, in considerable quantity, of shells or calcareous matter. These carefully mingled were worked up in a moist condition and moulded into bricks, which were hardened by drying. After this they were broken into fragments and smelted in an ordinary cupola furnace. It is claimed that the product was capable of being, without further melting or treatment, made into the finest penknives and other cutlery. The experiments seem to have been carried on under some disadvantages, the expenditure being limited to about £100, and, as a consequence, the appliances used being of a temporary and rude description. Notwithstanding this, about 500 lbs. of excellent steel are stated to have been made at the first trial, and if the reports are correct, the experiment may yet lead to the utilisation of the vast deposits of this sand, of which so much has been said, and with which so little has been done. Any step forward in methods of working up this neglected ore should be deemed worthy of being followed up by those interested in iron industries.

For about seventeen miles along the coast of the province of Taranaki (or New Plymouth), New Zealand, there is nothing to be seen but a dull smooth beach, of a dreary black hue, which is deepened by contrast with the snowy foam. The beach is half a mile wide at low water, and its constituent particles have a slight metallic lustre, and are so small as to resemble fine gunpowder. They are much heavier than ordinary sand. Strange to say, this long and naked strand consists of myriads of tons of steel in a granular form—pure, excellent steel, of very fine quality. Formerly this black dust was thought to be valueless, and was trodden under foot by the careless native, and regarded by the unconscious colonist as of no more worth than the materials of which ordinary sea-beaches are composed. Now, knives, needles, chisels, swords, bayonets, gun barrels, implements of peace and weapons of war, have been made of it, and it is bought and sold for many pounds the ton. It has been carefully analysed in this country, and pronounced to be the purest ore at present known; containing 88·45 per cwt. of peroxide of iron, 11·43 of oxide of titanium, with silica, and only 0·12 of waste.

Taking the sand as it lies on the beach and smelting it, the produce is about 50 per cent of iron, of the very finest quality; and again, if the sand be subjected to what is called the cementation process, the result is a tough first-class steel, which, in its properties, seems to surpass any other description of that metal at present known. Deposits of this iron-sand are most frequent on the western coast of the North Island, and on the eastern coast of the Middle Island; and in the sands of many of the streams it is also found in great quantity. At New Plymouth, this magnetic sand covers the shore for miles. It consists of the peroxide and protoxide of iron mixed, and yields from 38 to 50 per cent. of iron, of the finest quality. Attempts have at various times been made to utilise this sand, and small quantities have been sent to England, where it has been manufactured into steel and cutlery; up to the present time, however, nothing of any commercial importance has been accomplished in the way of practically developing the material. Samples of this sand, as well as cutlery manufactured from it, were shown at the New Zealand Exhibition, at Otago, in 1865. Specimens of iron-sand from Otago were also exhibited, comprising black magnetic iron-sand, titaniferous sand, rhodonite, or silicate of manganese and iron.

Several of these black sands were carefully examined by competent parties, and the following explanatory notes are intended to show the relative proportion of iron which they contain:—

1. Magnetic and titaniferous iron-sand, Stewart's Island.—A remarkably pure iron-sand, containing 71·50 per cent. of magnetic iron; it is non-auriferous. The specific gravity of the whole sand as collected is 5·882, that of the magnetic part being 5·832. The assay gives 25·97 per cent. of titanic iron and 2·53 of silicious sand. It contains 8·21 titanic acid.

2. Magnetic black sand, Dunstan Diggings, Otago.—The greater part of this is much affected by the magnet. It is a mixture of coarse and fine sand. It is the common black sand of the Molyneux River, and is derived from the chloritic schists principally, in which it occurs as small isolated crystals. It forms a large proportion of the wash-dirt, and is very troublesome to the digger, being difficult to separate from the gold. It contains ·48 of gold, specific

gravity 4·960. The analysis gives it 82·77 of magnetic iron, 9·73 of titanic, and 7·02 of silicious sand.

3. Specular iron, or hematite sand, Tuapeka Diggings, Otago.—A very regular and fine-grained sand, only slightly affected by the magnet. It appears to be principally composed of peroxide of iron. It is auriferous. The proportions are 92·88 per cent. of hematite, 2·24 of magnetic iron, 4·88 of silicious sand.

4. Magnetic iron-sand, Musgrave's Run, Otago. — This is a very coarse sand, some of the grains being as large as swan shot. It is very much affected by the magnet, and is remarkably free from silicious impurities. Auriferous: 86·06 per cent. of magnetic iron, 10·51 of hematite, 3·43 of silicious matter.

5. Magnetic and titaniferous iron-sand, Taranaki ocean beach.—This sand is fine-grained, and powerfully affected by the magnet. The greater part of the impurities appear to be olivine. There are considerable mechanical difficulties to be overcome in working the sand into iron, arising principally from its minute state of subdivision. It is non-auriferous; contains 71 per cent. of magnetic iron, 8 per cent. of titanic iron, and 21 per cent. of silicious matters.

6. Magnetic sand, West Coast, Nelson.—Non-auriferous, and the richest in iron of any of the Nelson sands, containing about 55 per cent. of this metal associated with garnets of the manganesian variety. Analysis gives 75 per cent. of magnetic iron, and 25 per cent. of silicious matter.

7. Titaniferous iron-sand, Hooper's Inlet, Otago Harbour.—A coarse uneven sand, but slightly affected by the magnet. It does not contain gold; is sometimes known as "gem sand," from the crystallised quartz and garnets it contains. The analysis shows 20 per cent. of magnetic iron; 74·28 of titanic iron, with hematite; 5·72 of silicious matters.

8. Magnetic iron-sand, Arrow River, Wakatipu Lake, Otago.—A fine sand, very much affected by the magnet. The silicious substances are chiefly composed of quartz sand. Auriferous: 80 per cent. of magnetic iron, 7·61 of hematite, 12·39 of silicious matter.

9. Titaniferous iron-sand, Saddle Hill, Otago. — This was taken from a sample of the sand found upon the sea

beach nine miles from Dunedin. It is non-auriferous, and exceedingly fine-grained: it contains about 58·38 per cent. of magnetite; 25·66 of titanic iron, 15·96 of silicious matters, and 9·40 of titanic acid. This is a very similar sand to that from Taranaki, when separated from its more earthy matters.

As there is a prevalent impression that many of these black sands of New Zealand contain tin ore, that metal was carefully tested for in every sample examined, but without its being met with in a single instance.

To form some idea of the fineness of this beautiful sand, it will be enough to state that it passes readily through a gauze sieve of 4900 holes or interstices to the square inch. Very lately (1873) a Titanic Steel and Iron Company has been formed in Wellington, New Zealand, and the directors, consisting of many of the principal local merchants, have applied for a lease of eight and a half miles of tract from Waitara to Urenui. There are many other localities in which iron-sand is found, although not perhaps so abundant as in Taranaki—such as Victoria, King George's Sound in Western Australia, Assam, and parts of British India and North America.

The sands of the shores of parts of the Gulfs of Naples and Salerno contain magnetic and titanic iron ores, which in some cases form as much as 20 per cent. of the whole mass. As these sands are completely dry, it would be easy to separate the iron ore from them by means of a simple magnetic arrangement, and thus to obtain a substance fitted for the production of steel.

The Naples Colour Company use this titaniferous sand for making a paint for steel. This description of metallic sand appears to possess the remarkable property of not becoming oxidised when kept in a moist condition, and the special attention of chemists and metallurgists may be drawn to this fact, with the view of arriving at (what would be an invaluable discovery) the production of iron or steel that would not be subject to the destroying action of the oxygen of the atmosphere.

There exist large quantities of similar iron-sand in the northern portions of the United States and in Canada, the practical value of which is as indefinite and undecided as is the case with the deposits referred to on the other side of the world.

These so-called iron-sands are doubtless the result of the decomposition of rocks containing magnetic iron; and the particles of the magnetic oxide are usually quite pure and separate from those of ordinary feldspathic or quartzose sand which surround them. Dr. Sterry Hunt has called attention to the great extent of such deposits on the St. Lawrence, and along the coast of Long Island Sound. Every attempt to utilise them as iron ore must begin with the separation of the sand. According to Prof. Egleston, the highly titaniferous iron ores are mixtures of ilmenite or menaccanite in magnetile, from which, when pulverised, the latter can be separated with the magnet. The importance of machinery for cheap and rapid separation of magnetic iron from non-magnetic associated minerals will therefore be considerable, when the utilisation of the cleaned product is successfully accomplished. At Moisie, Canada, where the iron-sands are worked in the bloomary, a magnetic separation, employing permanent magnets, is in use.

A machine has been recently invented by Mr. A. H. Balch, of Baltimore, which differs from those hitherto used in the employment of electro-magnets instead of permanent magnets. It is claimed that the facility of alternate magnetisation and demagnetisation, produced by making and breaking the battery circuit, gives a much stronger and more certain and controllable effect, picking up the iron particles without admixture of sand, dropping them again when they are wanted, and cleaning the ore at a single operation.

This machine is fully described in a paper read by Mr. R. W. Raymond before the American Institute of Mining Engineers, at Philadelphia, Feb. 22, 1872, and published in the 'American Artisan,' of New York, shortly after.

The machines in which permanent magnets are used are subject (the magnets being without armatures) to the rapid loss of power. The magnets must be re-magnetised as often as once in three months. In this machine, the only inconvenience of that kind is the very slow acquisition of a slight permanent magnetism by the soft iron electro-magnets, which may require their annealing or renewal once in two or three years. The importance of the machine depends, after its excellence has been established, upon the

successful utilisation of the material it produces. The prospect in the direction of the blast furnace is both metallurgically and economically discouraging; but there remain the bloomary-fire, and the various processes proposed for the conversion of iron-sand into iron of peculiar qualities, or into steel. Experiments are continually making, from which, no doubt, some day, a satisfactory solution may be evolved.

The Californians are about to fish gold from the sea, and a large diving-bell is now being constructed in San Francisco for that purpose. It appears that the shores of Gold Bluff, on the northern coast of California, abound in the precious metal, but as the time between the ebb and flow of the tides is too short to allow miners to work with advantage, they propose to work under the bell, unmindful of the tides. Another plan has been devised. The black sand which covers the bottom of the sea all about that region is largely mixed up with gold-dust. They are building a schooner provided with a large vacuum pump, and an elastic tube six inches in diameter, which will cause the sand to rise in the vacuum chamber, and by this means they estimate that one hundred tons per hour can be elevated. Of course, the success of such enterprises depends entirely on the amount of gold obtained in return for a certain amount of labour and capital invested. When the machinery is judiciously constructed and properly managed, such an enterprise may pay as well as the ordinary mining in the hills and streams, and quartz crushing.

On the flanks of Monte Amiata a number of small basins are found, containing a white powdering substance of a highly silicious nature, called fossil flour, which when examined by the microscope, is found to consist entirely of the remains of Diatomaceæ and other important organisms. Several attempts have been made to use this substance for the manufacture of tiles and refractory bricks, but the incoherent nature of the material causes the article to crumble rapidly into dust. A certain amount of cohesion may be obtained by an admixture of clay, but this is attended with an increase in the weight, and diminution in the power of resisting high temperatures. The articles made out of the pure fossil flour are sufficiently light to float on

water. Mr. C. Sante, of Montalcino (Sienna), has tried to use it in the preparation of colours, an application which may, perhaps, be of value in the manufacture of smelts and glazes; he also prepares floating refractory tiles by covering them with a peculiar kind of glaze. The fossil flour may be advantageously used, for grinding and polishing metals, instead of emery.

In the Spanish dominions ordinary brick-dust made from hard-burned finely-pulverised bricks mixed with common lime and sand is universally and successfully employed as a substitute for hydraulic cement. It is a regular article of commerce, sold in barrels by dealers in such articles at the same price as cement. The proportions used in general practice are one part of brick-dust and one of lime to two of sand, mixed together dry, and tempered with water in the usual way.

A Frenchman has patented an invention for pulverising the refuse of slate and mixing it with some substance which produces a most durable material, and which answers the same purposes as many kinds of our most valuable stone.

During the last few years experiments have from time to time been made with the view to utilise in some way the mounds of shale (the refuse of the coal mines) which cover an area of several thousands of acres in South Staffordshire, by converting them into bricks. Several enterprising firms have already embarked in this novel but profitable business. When properly pulverised, the shale is found to be an excellent material for the purpose, the bricks produced being hard and durable, resembling in colour the fireclay bricks of the Stourbridge district, although for furnace and such-like purposes they are not so valuable. For ordinary building, however, they are found to be of equal practical value to the common red bricks, the only possible objection to the former being their colour, which is somewhat too light for a smoky district like South Staffordshire. This objection, however, could only apply to their use for buildings of architectural pretensions, and such buildings in the black country do not predominate. There is every reason to believe that this method of utilising the innumerable dusky hillocks which disfigure the South Staffordshire landscape will gradually develop into an industry of some importance. The material is to be had

in any quantity for a merely nominal sum, and its exhaustion in those parts of the district where the collieries are worked out, would be doubtless followed by a restoration of the landscape to a much nearer resemblance than it now bears to its former beauty.

The 'American Builder' gives the following method of making sand-paper of a superior quality, at almost a nominal cost. The device for making sand-paper is simple, and at hand to any one who has occasion to use the paper. A quantity of ordinary window-glass is taken—that having a green colour is said to be the best—and pounded fine, after which it is poured through one or more sieves of different degrees of fineness, to secure the glass for coarse or fine paper. Then any tough paper is covered evenly with glue, having about one-third more water than is generally employed for wood-work. The glass is sifted upon the paper, allowing a day or two in which to become fixed in the glue, when the refuse glass is shaken off, and the paper is fit for use.

The Utilisation of Waste Materials in Mining.—Immense heaps of refuse, or "tailings," as they are technically termed, accumulate where mining operations are carried on. These contain a good deal of metal, but no way has yet been devised of extracting it economically. We have improved upon the ancients in that respect, and posterity may improve upon us, as suggested in the following extract from an Australian journal:—

"In the year 4000, or thereabouts, when the Anglo-Australian race shall have been 'played out' on this continent, and our posterity shall have degenerated as the Greeks have done, will the New Zealander of the period, accomplished in arts which are unknown to us, and armed with scientific appliances such as we have never dreamed of, come over to Victoria and extract tons of gold from the tailings in our desolate and deserted gold-fields? The question is suggested by what is actually taking place in Attica."

In the tailings of the stamping mills in Victoria, many tons of pyrites are allowed to run off and become lost, while they could be separated from the refuse by mechanical preparations. Gold is found in its metallic state in the colony mixed mechanically with iron and arsenical pyrites;

sometimes it is even perceptible to the naked eye, at other times it is not; and it is also found mixed with galena and zinc blende. Of the minerals enumerated, iron and arsenical pyrites are found in large quantities in the quartz gangue; but copper pyrites, galena, and zinc blende are seldom found, and then in insignificant quantities.

Some few years ago a gentleman in Forbes, Tasmania, of the name of Morse, who had had great experience in mining, both in Victoria, California, and New South Wales, discovered that the sludge which was emptied from the puddling mills contained a considerable quantity of fine gold—so fine as not to be discernible to the eye unassisted, and he turned his attention to the invention of some method by which it could be saved. In this he succeeded, and the method has been adopted by other parties, and made to work successfuly. The old sludge is thoroughly puddled, and then, in a very thin state, is turned into a box about twenty feet long and four feet wide, set perfectly level from side to side, and with an incline of about two inches to the foot. Upon this blankets are stretched. The liquid spreads over the surface, and the fibre of the wool catches nearly every particle of the imperceptible dust. The blankets are then washed, the sand is subjected to quicksilver, and the gold all abstracted. Mr. Morse has two of these tables attached to his puddling mill, and, by the economical means of working, is said to be realising very handsome returns.

As an instance of the accumulation of tailings, the Mining Commissioner, in his report on "Deep Place Mining" in California, gives some interesting details. I will quote one extract respecting Bear River:—

"This stream has been filled to a depth of nearly 80 feet in the centre, and its former banks so far covered that tall pine trees, formerly far above the stream, have been gradually engulfed, season after season, until now only the top branches appear above the current. It is believed that these tailings contain enough gold and quicksilver to pay a handsome profit for their removal if any outlet could be found.

"Mr. Uren, of Dutch Flat, a civil engineer and surveyor, has made a reconnaissance of the country between Bear River and the north fork of the American River, and states

that a tunnel could be run through the divide between these streams which would not exceed in length one mile and a half. As the American River runs through a gorge several hundred feet lower than Bear River, this tunnel would empty Bear River and its tributaries, and open millions of cubic yards of hydraulic ground now without outlet, which otherwise can never yield up its wealth. The quantity of tailings in Bear River and its confluent gulches alone, above the mouth of the supposed tunnel, estimating, on an average width of 300 feet, a depth of 75 feet, and a length of ten miles, would be 44,000,000 cubic yards. We know that in early times a large proportion of the gold and quicksilver was lost; perhaps 20 per cent. would be too low an estimate of such losses. Of late years the proportion of gold and quicksilver carried off in the tailings has been smaller; the amount could be approximated by careful calculations of the results of the cleaning up of the last system of undercurrents and tail sluices of the claims emptying into this river, and by some experiments at favourable points.

"Let us suppose, however, that the general average of the tailing will reach $2\frac{1}{2}$ cents per cubic yard, we have an aggregate of $1,100,000, to save which we must construct a tunnel of say 8000 feet, lay it in flume, and place it in condition for running off the tailings. With the present facilities for running tunnels, by means of compresed air, diamond drills, and giant powder, we should not estimate the expense per lineal foot at over $10 or $12—the rock being an easily worked slate—which would give an aggregate of $100,000. Allow $50,000 for putting in flume and incidental expenses, and we have a total cost of $150,000. Now, if 50 per cent. of the gross amount estimated to be in the river can be saved, we have a result of $550,000, less the expense of cleaning up and original cost of tunnel. The contents of these tailings have been estimated by Mr. Uren and others at much higher figures than above. After the tailings were run off, the tunnel would be valuable property as a tail-sluice outlet for many square miles of hydraulic ground. We have made the calculation out of curiosity, but think this is one of the profitable mining enterprises of the future.

"Another illustration of the extent of these accumulations

is afforded at the crossing of Shady Creek, near Cherokee, between the Middle and South Yubas. At this point there formerly stood a saw-mill on the banks of the creek: the boiler of this mill was supplied by a water-tank which stood higher up on the bank of the stream. The tailings from above so encroached on the mill that it was rendered useless and taken down; the tank, however, remained, and the timbers of which it was composed are now seen cropping up above the tailings, a distance of several inches. Another "run" will completely obliterate all traces of this landmark of early times. The depth of tailings here cannot be less than 70 feet."

The value of metallurgic skill has recently been strikingly demonstrated in Greece. Some time ago the Greek Government parted with, for a mere trifle, to two enterprising foreigners, their rights over the rubbish heaps at the Laurium mines, which were first worked 3300 years ago by the king of Athens, from the profits of which Pericles is said to have built the Parthenon. The mines of Laurium are some veins of argentiferous galena running between the mica schist and limestone formations of the promontory of Laurium, stretching from Sunium to Athens. From the remains of the ancient workings, there are now being obtained about 9000 tons of bar lead, lowered in value by being very antimonial, which contains above ten ounces of silver to the ton. It was soon found that even the débris, which had been cast aside by the ancients as worthless, possessed great value, and the Government, repenting of their bargain, are demanding more money for their rights.

The Franco-Italian company which obtained the concession to treat the scoria and other refuse for silver, now conduct their operations on so large a scale that a town containing 4000 inhabitants has sprung up on what was formerly a solitude; a railway has been constructed to the nearest port, and a small steam-vessel plies twice a week between Argosteria and the Piræus for the transport of the argentiferous tailings to the roasting furnaces.

Ergasteria, called into life in 1865, is now a thriving and growing establishment, containing about 3000 souls, and on the works of which nearly £60,000 are laid out yearly.

Extensive beds of scoriæ, the refuse of the silver and

lead mines worked during eight centuries by the ancient Athenians, became at the termination of the Greek revolutionary war the property of the villagers of Keratia, from whom they were purchased by a company, represented by M. Roux, an enterprising capitalist of Marseilles. The company in question, which comprises Italians and Greeks, obtained, by a law passed in 1865, the right to work the old mines of Laurium, paying 25 francs duty on each ton of lead exported. The annual export of lead is now from 7000 to 7500 tons (value £177,000), all of which is sent to England. The proportion of silver found in the lead is said to be about half per cent. There are twelve furnaces constantly at work, and three engines of from 40 to 80 horse power. From 3 to 3½ per cent. of lead remains in the rejected scoriæ, the proportion left in the refuse of the ancient mines being 10 per cent. The scoriæ beds, in the midst of pine-covered hills, are from 80 to 100 yards wide, and are computed to contain 1,000,000 tons.

From 1864 to 1871 inclusive, the returns made to the Department of Mines in Victoria show that $1{,}501{,}024\frac{5}{20}$ tons of quartz tailings, mullock, &c., have given 280,397 ozs. 17 dwts. of gold, or an average of 3 dwts. 17·66 grs. per ton; and during the nine months ending September, 1872, $102{,}250\frac{3}{4}$ tons of similar vein stuff yielded an average of 3 dwts. 3·66 grs. per ton.

It is strange that the method of treating pyritous vein stuffs, in use in some parts of America, should not have been tried on a large scale by the Australian miners. At Sandhurst there are immense heaps of tailings containing auriferous pyrites, which, if properly stacked, would yield nearly all the gold they contain at but little cost of money or labour. Mr. R. Brough Smyth, F.G.S., Secretary for Mines in Victoria, remarks:—"One mine owner at Sandhurst informed me when I was last on that gold-field, that he had sold the right to wash a large heap of tailings to the Chinese there several times, and that each time the men seemed satisfied with the result of their labours. I am not able to give an exact statement of the loss of weight there would be by oxidation in a stack formed of pyritous tailings, small coal, gum leaves, &c., but it would probably exceed 20 per cent. Mr. Cosmo Newbury states that his experiments in roasting pyrites show a constant

loss of 50 per cent. If some of the mine owners would make the experiment I have suggested under the direction of a chemist, the results, I believe, would be such as to give an increased value to the large heaps of tailings on the gold-fields, and lead, probably, to the re-working of many abandoned pyritous veins."

The yield of gold from pyrites and blanketings in Victoria during the years 1869 to 1871, was at the rate of 2 ozs. 14 dwts. 5·86 grs. per ton; the total quantities operated upon being $8142\frac{16}{20}$ tons. In the nine months ending September, 1872, $3629\frac{3}{4}$ tons yielded an average of 2 ozs. 11 dwts. 22·05 grs. per ton.

Pyrites are treated on, perhaps, a larger scale at the Pioneer Company's Works, Long Gully, than at any other establishment in Victoria. About 25 tons on the average are treated per week, the yield being at the rate of 3 ozs. 6 dwts. 4 grs. per ton. The pyrites are caught on blankets placed at the ends of the ripple tables, and the blankets are washed over every two hours. The blanketings are concentrated by buddles, of which there are two. The ore, after roasting in the reverberatory furnaces, two in number, is put through three Wheeler's pans charged with mercury. The charge made for treating the ore is £3 per ton. The system of reduction and treatment of the vein stuff adopted at these works is that most generally approved of at the present time. The machinery cost £26,120, and the men employed number 106.

The quantity of gold used in the arts of frame gilding, in interior and exterior decorations (a taste for which is greatly on the increase), in photography, electro-gilding, "water"-gilding, and other similar processes, and in the ornamentation of china, porcelain, &c., must be enormous. The gold thus employed may be considered practically lost to us for ever, and when we bear in mind that this absorption of the metal takes place not only in this kingdom, but in almost every part of the civilised globe, it becomes a question whether the annihilation of so large a quantity of this metal may not ultimately affect its commercial value. Should the gold-fields of Australia and California hereafter become less productive than at present, while the employment of gold in the arts referred to annually absorbs many thousands of ounces of the precious metal,

is it not reasonable to infer that we shall suffer for it by-and-by?

Collection and Reduction of Photographic Wastes.—Photography now withdraws a considerable quantity of silver and gold from the arts and from monetary circulation. It is the duty and the interest of photographers to preserve all the residues which have any value, and to study how to re-utilise them. Among these residues may be ranked the clippings of paper, the photographs badly worked, or which are rejected as unsatisfactory to the sitters, as well as the papers through which the solutions of silver and gold are filtered. Mr. Helm, of Dantzic, writing on this subject in the 'Technologiste' of Paris, states that each kilogramme ($2\frac{1}{5}$ lbs.) of these residues contains about 31 grammes of pure silver, and nearly 11 or 12 centigrammes of gold.

Besides these shreds there is the filtering from the silver solution, which contains a large proportion of the metal. To recover these residues, they should be burnt and reduced to ashes in a suitable furnace which does not draw too quickly. The ashes are carefully collected and digested with an equal weight of hydrochloric acid, which does not contain nitric acid. After having removed all the hydrocloric acid by hot water poured over it in abundance, the residue is very nearly purified from all foreign metals. It is then dried and mixed with an equal weight of carbonate of soda, to which is added from 10 to 15 per cent. of saltpetre, and it is melted at an intense heat to form a regulus. This regulus usually consists of silver chemically pure; but in some cases contains small quantities of copper, lead, or bismuth. To prepare nitrate of silver from the latter, the solution in nitric acid is purified by means of crystallisation, and in the other caso it is left as it is.

The gold which remains in the nitric solution, in order to be recovered pure, is dissolved anew in aqua regia filtered, and the liquor evaporated, &c.

In this manner many pounds of pure silver previously wasted can be recovered. It may, however, be remarked here that in reducing the salts of silver, alkalies containing silica or crude potash should not bo used, for in that case the silver recovered would bo found to contain silica, which would not dissolvo readily in nitric acid or part with the silica.

Dr. Gräger has proposed a new method for the regeneration of waste nitrate of silver solutions used in photography. After first referring to the generally applied and well-known means now in use for this purpose, he states that the best plan to treat these solutions is the following: They are boiled either in a porcelain basin or a glass flask, and, while boiling, there is added to them recently precipitated, well-washed, and moist oxide of silver, the boiling being continued for some time. The liquid is next filtered, and then evaporated to dryness, the heat being increased to fusion, so as to destroy ammoniacal salts; the residue is pure nitrate of silver. The sediment on the filter contains some oxide of silver, which must be added in excess; and therefore, in order not to lose that, the filter is preserved, and the contents worked up at a subsequent operation. The nitrate of silver thus obtained is, by practical photographers, pronounced to be of excellent quality.

A firm of photographers at Wakefield, during the last three years, have carefully collected their defective pictures, clippings, sweepings, washings, &c., burning the former from time to time to ashes, and precipitating the silver by common salt. To every pound of chlor-silver obtained, half a pound each of carbonate of potash and soda crystal in powder was added, and the whole fluxed. Two bars of pure silver alloyed with a little gold were thus obtained, weighing together 170 ounces troy, which have realised £44 1*s.* 1*d.*

Mr. J. Shaw, of Bridgeport, Connecticut, lately patented an invention which consists in the employment or use, either in combination with the basin or sink into which persons using solutions of gold or silver suffer them to be wasted, or in place of said sink or basin, of a vessel so arranged and constructed, that the waste solution while running through said vessel shall be brought in contact with such chemicals or metals as will cause the whole or any part of the silver or gold contained in the solutions to be precipitated and retained in said vessel, while the worthless material is allowed to escape. It consists further in the use of a partition or its equivalent in said vessel or sink, for the purpose of forcing the precipitated silver or gold to the bottom and preventing it from being drawn by the force of the current directly to the filter or outlet; it

consists finally in the employment of a filter or its equivalent in combination with the sink or vessel in which the waste solution collects, in such a manner that said filter will retain any particles of silver or gold which might still float in the liquid after being brought in contact with the chemicals and passing under the partition.

Dr. Von Monckhoven recently published the following instructions as to the recovery of pure silver from photographic residues :—

1. From old baths.—First filter, then add ammonia until the precipitate first formed is re-dissolved; then add sulphite of ammonia, or pass a current of sulphurous acid gas. Afterwards heat the liquor to about 104° Fahr. for about an hour, when all the silver will be precipitated in a state of absolute purity. This method was first suggested, I believe, by M. Stas. After washing the silver, a powder obtained as above may be at once dissolved in nitric acid to form nitrate.

2. From washings.—The washings may be collected in a barrel in which a sheet of copper is placed. The silver will be precipitated in about twenty-four hours. When the liquor has been often renewed, and a quantity of gray powder of silver has collected, it may be dissolved in nitric acid, and treated with ammonia and sulphide of ammonia as above.

3. From paper.—Burn the papers one by one so as to get a white ash. Weigh the ashes and treat them with an equal weight of nitric acid diluted with twice its volume of water. All the silver will be dissolved. Filter, and pour the solution into the barrel containing the sheet of copper. Treat the precipitated silver as before.

4. From chloride of silver.—This may be at once dissolved in ammonia and treated with the sulphite. The silver will be precipitated quite pure.

The method is not applicable to old hyposulphite. In all other cases it is easy to follow, and furnishes chemically pure silver. Every salt of silver dissolved in ammonia and treated with the sulphite is reduced. In liquors heated as directed to 104°, the precipitation is completed in about half an hour; but in the cold, twenty-four hours are required, at the end of which time the precipitation is perfect.

The 'American Chemist' publishes the following process to recover gold and silver from trimmings of photographs

which have been fixed and toned. It is recommended to burn the papers carefully, and then to treat the ash with chlorine gas to convert the precious metals into chlorides. The ash may then be thrown on a filter, the gold chloride separated from the silver chloride by washing, and the two reduced at pleasure. The recovery of gold from the slips by means of ferrous sulphate is extremely faulty, if it is intended to use the gold afterwards for photographic purposes, as iron, in the form of a basic ferric salt, is almost sure to be mixed with it. Kniger recommends precipitating the gold by the addition of ammonic chloride and hydrochloric acid, which precipitates it absolutely pure.

Not less than £100,000 worth of gold and silver is said to be annually consumed by the photographers of the United States, and fully one-half of this it is believed could be saved by proper care.

Mr. C. L. Lortman published lately, in the 'Scientific American,' the details of the plan he uses in the collection and reduction of photographic wastes.

1. All clippings of silvered paper, old filters, paper charged with drippings from silver solutions, &c., should be kept in a suitable box; and when a sufficient quantity has been collected—from 10 to 15 pounds—they should be reduced to ashes in the corner of a clean hearth, by having a little square place built up with a few loose bricks. Throw into this place a few handfuls, set fire to them, and add the remainder gradually, while keeping up a pretty good fire. When all the waste has been burnt in this way, keep the ashes in a pile and let them be converted into gray ash. I am particular in describing this process, as the future success of reduction depends very much on the complete combustion of the waste paper, so that very little charred paper is left, all being reduced to gray ashes, which consist principally of the silica of the paper and partly reduced silver.

2. All the washings of the prints may be collected in a suitable vessel and the silver precipitated as a chloride by means of common table salt; too much salt should not be added at a time, as the chloride is soluble in a large excess of salt. When a sufficient quantity of chloride of silver has been collected, drain it on a muslin filter and dry it thoroughly. Treat in a similar manner the washings of negatives and the waste developing solution. Or both may

be precipitated together in a vessel—say a common tight barrel, cut in two—which should be kept in the dark room. The clear liquid must be drawn off from time to time, by means of a siphon or a tap, placed three or four inches from the bottom. The precipitate consists principally of chloride of silver.

3. The hyposulphite of sodium, or fixing solution, should be collected separately in a capacious stone jar, and the silver thrown down by keeping a piece of zinc constantly in the liquid; and when the jar gets full of solution, the supernatant liquid is poured off. When a suitable quantity has been collected, drain off the chloride on a filter and dry. When perfectly dry, place this waste, which consists of sulphide of silver and metallic silver, in a sand crucible—an old one that has been used for reducing silver will answer—and expose to the heat of a common stove, merely to expel moisture and sulphur, or, in other words, to roast it.

4. Waste toning or gold solution is more economically collected by pouring it in a shallow dish and evaporating it to dryness on a stove or in the sun. This consists of the various salts used in toning, generally bicarbonate of sodium and chloride of gold, the latter being more or less reduced to a metallic state. The soda will be useful as a flux in the operation of reduction.

The reduction of the wastes to their metallic form is done in a very simple manner and with perfect success, if the following method is carefully carried out:—A common stove, one with an egg-shaped cylinder, or one having a similar open fire-place, will answer exceedingly well, if it has a good draught; this latter is an essential. The fuel should be either common anthracite or bituminous coal or coke. The best flux for the various wastes, is simply salt of tartar (carbonate of potassium). A sand crucible of the capacity of from a pint to a quart, a pair of tongs, a small scoop with a long handle—an iron ladle will answer—and a common poker, are all the necessary implements.

Build up a fresh fire in your stove, introduce the sand crucible, which has been previously filled to the top with an intimate mixture of your waste—either of one kind, or all mixed together—with two or three times its weight of salt of tartar. Put coal around the crucible as high as the top, and give the stove its full draught. In the course of one

or two hours the contents of the crucible will melt into a liquid mass; you may then add with the scoop more waste, mixed as above with salt of tartar. This has to be done very gradually, or the gases set free will cause the crucible to boil over. In this way, a quantity as large as that first introdueed into the crucible may be added. When the whole mass assumes a liquid form, try, with a hot poker, whether the mass is homogenous; if it has tough lumps in it, add cautiously some salt of tartar, keeping up a strong heat in the mean time; and when the mass becomes uniform, remove the erueible from the fire, taking a firm grip with your tongs, and either pour out the mass into a dry iron vessel, or set the erucible on the front of the stove or on a brick to cool. When cold, you will find the metal in a button, either in the bottom of the erueible or the inner vessel, as the ease may be.

The gold waste, eollected as stated above, should be mixed with the other waste, and the soda eontained therein will answer as a flux in eonneetion with the salt of tartar; the gold mixed with the silver can be separated as directed further on.

The process of reduction takes from three to four hours, and a strong white heat must be kept up. The materials must be perfectly dry. No small globules of silver should be found interspersed in the flux. If they are found, it is because the heat is insufficient, or the erucible was removed too soon from the fire. The paper ashes should furnish one-half or three-fourths their weight of metallie silver. One and one-fourth to one and one-half parts of ehloride will yield one part of silver, and the other waste from one-half to three-fourths its weight.

To convert the metals into nitrate of silver and chloride of gold, dissolve the metal in a poreelain dish, in a ehimney place, by adding two and one-half parts of commercial nitric acid to two parts of the silver; use the heat of a very small gas jet or small kerosene lamp plaeed under the dish. To prevent the projection of liquid from the dish, invert a glass funnel over it, resting just inside the edge of the dish. When the silver is dissolved, remove the funnel and evaporate with a stronger heat until dry. It may be used in this state for photographic purposes, or the mass may be dissolved in water, poured off from the

black sediment (which consists principally of gold), filtered and evaporated again until a pellicle begins to form on the surface; and then, being removed from the lamp, it is set aside to crystallise into nitrate of silver. The mother liquor may be used in solution or again evaporated to crystallisation. The gold, remaining in black powder, is converted into a chloride by adding to it a small quantity of aqua regia (nitric acid one part and muriatic acid three parts) in a glass or porcelain vessel, and evaporating to dryness over a water bath.

Mr. F. York also publishes the following practical hints on the treatment of residues and old baths :—

As a rule, photographers are dissatisfied with the refiner's valuation of their residues, and generally fancy they have been more or less swindled. The principal product is the silver washings in printing, which are generally thrown down as chloride, which must pass through the refiner's hands. The fixing and developing solutions do not bear a relative value to the chloride, so they may be sent to the refiners as usual. The plan I wish to recommend is to precipitate the silver washings with a sheet of copper suspended in the tub; this, with occasional stirring, will precipitate the whole of the silver in a metallic state, which may be collected once every three months, and, after repeated washings in ordinary water, be dissolved in nitric acid. This must be added gradually until the whole of the precipitated silver is dissolved; evaporate to dryness, redissolve, and neutralise with carbonate of soda, filter, test with the argentometer, and make a stock solution for strengthening the silver sensitising bath. The trouble is nothing compared to the satisfactory result. It may be done on dull days. In dissolving the silver, place the evaporating dish on the hob of the grate, that the nitrous fumes may escape up the chimney. My stove is a little ring burner, connected with the gas by an india-rubber tubing, and an Australian meat tin with the top and bottom out. Paraffin casks make capital residue tubs after burning out the paraffin, which do not attempt to do except in the open air. Insert a wooden tap one third from the bottom; if you have room use two tubs, so that one may be settling whilst the other is in use. The developing solution requires no particular attention, as the iron is

sufficient to precipitate all the silver; still some strips of copper may be suspended therein.

The hypo fixing may be precipitated with copper or sulphuret of potassium. This product is more valuable than most people imagine. I find it worth about one-sixth of the value of the silver used in printing.

When old baths get saturated with alcohol or iodide, do not attempt the many dodges of diluting, sunning, strengthening, or evaporating; the result is always an old bath. Try the following, which will convert it into a new one; precipitate the idodide of the silver with citric acid, filter into a wide-mouthed bottle, in which stand a thick piece of copper; this will precipitate all the silver in a metallic state, leaving nitrate of copper in solution. Pour this off into the residue tub and wash the metallic precipitate about ten times, then dissolve it in nitric acid, which add gradually, and on the hob; when the silver is dissolved evaporate to dryness, dissolve and add oxide of silver to it until neutralised, and any copper held in solution is precipitated as an oxide; filter and add one drop of strong nitric acid to each pint, and you will have a new bath. Oxide of silver is made by precipitating some of the old silver bath with liquor potassæ, and repeatedly washing the precipitate. It may be used over and over again, in fact a stock bottle may be kept purposely for neutralising.

Recovery of Tin from Tin-plate Scraps, &c.—Two facts make the utilisation of tinners' clippings especially desirable. The thin iron used for plating with tin is of the very best quality, and is, of course, worth saving, if possible; and, in the second place, the scarcity of tin and the immense demand for it make it a desideratum to avoid wasting the latter metal. In plating, the iron becomes more or less alloyed with the tin, and, unless the tin can be entirely separated, the alloy is "cold-short," or brittle when cold, and therefore worthless.

In the manufacture of tin ware, there is a large waste of the raw material, in the shape of clippings and pieces, and as this waste consists of the two useful metals, iron and tin, attempts have been made from time to time to reclaim each metal separately, with a view to utilise them. The tin, which demands, from its great value, the highest

consideration, is first separated from the iron by an acid, and afterwards by chemical means restored to the metallic state; but the difficulty has hitherto been to keep the restored tin quite free from iron—the presence of which, though in minute quantities, effectually neutralises the most valuable property of the tin. The great bulk of these clippings, however, is iron, which, by the process of heating and melting, can be re-formed into bars; and as a large proportion of the tin-plate used in the manufacture of tin ware is composed of charcoal iron, a very fair quality of bar iron might with care be produced; but this can only be accomplished by the introduction of hammers into the furnace itself, whilst the iron clippings are hot, as from their slight substance they would not retain sufficient heat, if withdrawn, for the hammering process in the ordinary way.

The total estimated make of tin-plate in the United Kingdom is set down at over 2,500,000 boxes, of variable weights.

Of this quantity about 2,500,000 cwt. are exported, roughly valued at nearly 4,000,000*l.* sterling. There must be many hundred tons of clippings alone produced in this country, besides the old tinned articles thrown aside as useless. As there are 6 or 7 lbs. of tin to every 100 of clippings, from every hundred tons of this refuse material we might obtain 5 or 6 tons of tin, besides the 90 tons of iron. The loss from dirt is comparatively trifling when operating upon new clippings. The clippings are, I believe, used as a flux in the smeltings of antimony ore.

The utilisation of waste tin-plate scraps has formed the subject of many inventions which have been patented, and several countries are operating in this direction. In 1861, Messrs. Edward and Charles Kuhn, chemists, of Sechshaus, near Vienna, took out a patent for producing pure tin, good weldable iron, ammoniac, Prussian blue, and some minor products from the waste clippings of white iron.

Mr. Higgin, of Manchester, now utilises the tin from waste tinned iron (scrap tin) in the manufacture of stannate of sodium.

By the patented process of Henry Panton, of New York, the tin scrap is placed in a revolving inclined box, pro-

vided with hollow journals, through which is passed dry chlorine gas, so as to form and carry over to a condenser bichloride of tin, which is precipitated as oxide and reduced. The iron is formed into hollow ingots and melted to form steel, or worked into bars.

The description of a process invented by Mr. Frederic G. Martin, of Bermondsey, London, will be of value to those who are interested in this new industry.

The scraps, or clippings, are first cut into suitable lengths, and freed from dirt and other impurities by a revolving drum. When sorted, they are placed (say in quantities of about 1 cwt.) in a suitably perforated box or receptacle of any convenient shape, made of wood, to withstand the action of the acid, and provided with axles or trunnions, and with a door or cover for the purposes of filling and emptying. This box or receptacle having been charged with scraps or clippings, is then lowered into a suitable vessel, containing, say, about 20 cwt. of muriatic acid (otherwise called hydrochloric acid), of the ordinary full commercial strength—say 32° Twaddel—and at a temperature of about 60° Fahr., and, in this acid, the perforated box or receptacle, with its contents, is caused to rotate. In about half an hour, the action of the acid removes the tin from the iron plate of the scraps, the dissolved tin remaining in solution in the acid, leaving the iron plates of the scraps in the perforated box or receptacle, which is raised, with its contents, out of the acid, and allowed to drain, for the purpose of saving such acid as may be adhering to the plates.

After draining, the perforated box or receptacle is immersed, with its contents, in water, to remove all acid from the surface of the iron plates. The plates are then placed in some material which will absorb all the moisture; lime is preferred, because it is beneficial in fluxing the iron and destroying the sulphur. To remove lead or other impurities that may be present, the plates are placed in a reverberatory furnace, and heated to from 700° to 800° Fahr. The iron product thus obtained is made into plates which are pressed into bales, and utilised in the ordinary manner.

The muriate of tin in solution is allowed to stand, to allow the settlement of any iron and impurities that may

have been removed by the acid from the plates. Twelve hours generally suffices for this operation, at the ordinary temperature of 60° Fahr.

A siphon is then introduced into the clear solution above the level, for iron and other deposit, and the pure muriate of tin is thereby drawn off into suitable receivers. At this stage the muriate of tin will be of a strength of about 60° Twaddel (this strength varying with the temperature according to the season of the year), and will contain only about half the quantity of tin it is capable of saturating; and, in order to carry on the process with advantage commercially, for the manufacture of paper-foil, it is desirable that the acid should be made to saturate as much tin as possible without forming crystals.

For this purpose it is placed in a vessel—preferably of copper or earthenware—and to it the tin, in a granulated form, is added, the mixture being heated to 120° Fahr., care being taken not to exceed that. This temperature having been kept up for about five or six hours (when the atmosphere is about 60° Fahr.), the compound is allowed to settle, its strength then being 120° Twaddel.

It now resembles the muriate of tin ordinarily prepared from ingots of tin for the manufacture of paper-foil, and may be similarly utilised for that purpose, the process being as follows. The muriate of tin is diluted with water, and plates of zinc are introduced into the solution. The free acid remaining in the diluted muriate of tin dissolves the zinc and precipitates the tin in the proportion of about 32 parts by weight of zinc dissolved by every 54 parts by weight of tin thrown up. The tin thus precipitated is collected and washed, and thereby the acid and the zinc are neutralised. The tin that has been precipitated and washed is then mixed with animal size, and is spread on paper by means of brushes, and the paper thus coated with tin and called paper-foil, is passed between heated friction-rolls, whereby the tin surface is calendered or finished, so as to give it a polish or brilliant appearance, ready for the market.

The muriate of tin obtained by the above process may also be used for other purposes than for coating paper.

A corporation known as the Manhattan Metal and Chemical Company has recently been formed in the city of

New York for the recovery of the valuable material from tin clippings. The process, which has been patented, is as follows. The tin scraps are first treated with hydrochloric acid of 20° Baumé until the bath is exhausted; 2 or 3 per cent. of nitric acid and about 1½ per cent. (of the amount of hydrochloric acid) of chlorate of potash is then added, which in a measure regenerates the bath, so that 500 lbs. of hydrochloric acid is found sufficient to treat 1 ton of scraps. About 1200 lbs. of clippings are placed in a drum which revolves successively in several vats or tanks charged with the liquors used in the process, being transported from one to the other on an elevated tramway. The first vat contains hydrochloric acid. The tin being dissolved, the drum is inserted in the second vat, which is filled with water, and then allowed to rotate for a few minutes. A second washing in water follows, in order that the iron scraps may be completely freed from acid, and finally the drum is plunged in a weak solution of silicate of soda, which forms a coating over the scrap iron and prevents its rusting. The time required to treat one charge averages about 1 hour and 15 minutes. The tin is precipitated by spelter, in a metallic form, ready for melting, while there remains in solution chloride of zinc and chloride of iron, which are valuable for the preparation of paint, as disinfectants, or for the preservation of timber. The estimates of the Company show a gain as follows:—From 1 ton of tin scrap there will be obtained 1800 lbs. of best refined scrap iron, $36; 100 lbs. of pure metallic tin, $35; 50 gallons of chloride of zinc and iron, 29° Baumé, $12.50. Total, $83.50. The whole cost of chemicals, labour, fuel, &c., being $29.05, leaves a net profit of $54.45 per ton.

Mr. Adolphe Ott has taken out a patent in the United States for utilising tin-plate cuttings, by which, in three months, more than 300 tons of tin-plate cuttings were worked up. There is not so much novelty in the chemical process as in the employment of suitable apparatus. The tin-plate cuttings are placed in a drum made of thick sheet-copper, perforated with a number of holes, ⅜-inch in diameter and 2 inches apart from one another. It holds, on an average, 1000 lbs. of cuttings. It is first allowed to rotate in an acid bath, in which the tin (or tin and lead) is parted

from the iron; it is then raised by means of a crane into a water bath, and from that into an alkaline bath, and finally again into the water bath. In the first bath the drum is allowed to rotate for from 5 to 50 minutes, according to the quantity of free acid; in the others, which only serve to wash away the acid, for 5 minutes in each case. On an average the operation of filling and emptying the drum, and passing it through the four baths, occupies 70 minutes; and, as one drum contains 1000 lbs., in one day of 10 working hours 90 cwt., or 4½ tons, of tin-plate cuttings may be worked up with ease. In the acid bath about 5 per cent. of iron is dissolved, in addition to the lead and tin. From this solution, after it has been drawn off into proper receiving vessels, the lead is first separated, after which, by the introduction of zinc plates, pure tin is precipitated. The latter is obtained partly in well-formed crystals, but chiefly in a spongy state. After being well washed in water it may be melted in an iron boiler, and cast into block-tin for sale. As, by the precipitation of the tin, zinc passes into solution (one part of zinc precipitates about two parts of tin), a solution of salt of zinc and iron is finally obtained, which may be employed either for preserving timber from rotting, or as a disinfectant, or in the manufacture of various paints.

The cuttings, when purified from the tin, are packed in casks and sent to the ironworks. The whole of the operation may be performed by six men. With regard to the cost of the acid and zinc, it amounts to about $16 per ton; $2 to $3 per ton are paid for the tin-plate cuttings—they being assorted and regularly delivered at the factory. The iron obtained fetches $30 per ton, and the tin, if free from all traces of lead, $35 per cwt. This process is in use in Germany, and at the works of Messrs. Dupont and Vielvoyt, in Brussels.

Ochre Refuse.—The 'Western Morning News,' observing that immense sums of money are made by catching tin which escapes in the water used in tin-dressing, says that the water which flows through the county adit contains a large quantity of sediment, which some enterprising individuals noticing, they took at a low rental a piece of ground where the adit discharges itself, and there made a number of catchpits, much after the manner of tin-streamers.

In these pits the water flowed, and being left to settle, the sediment remained. This, after undergoing some other inexpensive and simple processes was sold as ochre for making paints, also, instead of lime for purifying gas; and afterwards for manure. It is stated that the quantity of ochre sold from these pits in 1872 was about 2000 tons, at prices varying from 11*s*. to 25*s*. per ton; but like tin streams, the county adit does not give its riches to one person. Further on, nearer the sea, another man is said to have made £300 the last year by catching the refuse from the first catch-pits. This fact, the writer says, is but another proof that if men will but take advantage of their opportunities of acquiring wealth at home, they need not go to foreign countries for fortunes.

What is dirt? Why, nothing at all offensive, when chemically viewed. Rub a little alkali upon the dirty grease-spot on your coat, and it undergoes a chemical change and becomes soap; now rub it with a little water and it disappears. It is neither grease, soap, water nor dirt. That is not a very odorous pile of dirt which we often meet with in a dust-heap; well, scatter a little gypsum over it and it is no longer dirty. Everything like dirt is worthy our notice as students of chemistry. Analyse it; it will separate into very clean elements. Dirt makes corn, corn makes bread and meat, and that makes a very sweet young lady, that we sometimes kiss. So after all, we may kiss dirt, particularly if she whiten her face with chalk or fuller's earth; though I may say that rubbing such stuff upon the beautiful skin of a young lady is a dirty practice. Pearl powder, I think, is made of bismuth—nothing but dirt. Lord Palmerston's fine definition of dirt is "matter in the wrong place." Put it in the right place, and we will cease to think of it as dirt.

Dust ho!—An extract published in the 'Standard' in March 1871, contained some interesting details respecting the dust-heaps of London:—

"Travellers by the South-Western line from Windsor must often have looked down near the Vauxhall station on a yard with huge heaps of cinders, ashes, and the miscellaneous emptyings of dust-bins, on which women and girls were busy sifting and picking over the contents of their sieves, which men industriously kept filling—by no means

a pleasant sight, suggesting most unsavoury reflections, and raising many thoughts of pity, especially for those of the weaker sex engaged in this decidedly filthy and apparently unhealthy occupation. This is one of the many yards in the metropolitan district owned by 'dust contractors' or 'scavengers' (most of whom add to their business cards the title of 'manure merchants'), who collect the contents of dust-bins, road scrapings, and stable manure from all parts of the metropolis. When they employ their own horses and carts for this purpose they are paid by the different local boards and vestries for removing the dust; but where it is delivered for them, as in the case of the Commissioners of City Sewers, there is no payment made on either side; but in all cases stable refuse, as being more valuable, is paid for by the contractors. The three abovenamed superfluities of a town population are shot down into different parts of the yard to be differently treated. The 'pure' manure, out of which the contractor gets his best profit, is either fetched away in the carts of suburban and more distant market-gardeners; or, if the yard has a river frontage, it is sent up or down in barges, and finds its way by canals and rivers to different parts of Middlesex, Surrey, Kent, and Essex for agricultural purposes. The manipulation of the 'dust,' under which generic name is included the *omnium-gatherum* of the dust-bins and ash-pits, is a much more complicated matter; and the severing of their contents and ultimate sale and re-use is an intricate, if not very interesting, process. To effect this a sub-contractor, or 'moulder,' as he is termed in the trade, is employed, who contracts to sift the dust at from 6*d.* to 9*d.* per load, according to its quality, which varies according to the district from which it is brought. For this purpose he employs girls and women, in the proportion of three to one man, who can keep three sieves at work. A strange and repulsive sight, certainly, is one of these yards, with its miniature mountains of refuse, which Mr. Boffin, of Harmony Jail, rechristened Boffin's Bower, thought so picturesque as contrasting with the surrounding flatness of the scene. At the foot or rather some little way up the side of the ash mountain, are the women and girls, from twenty to sixty or more in number, according to

the business done in the yard, with their sieves in hand, being 'fed' by the men, who fill them from the un-carted refuse on which they stand. Between each pair of women, standing some yard and a half apart, are three large baskets, called 'siders,' the etymology of which is somewhat uncertain, unless they are so called from the baskets which the dust collectors hang on the 'sides' of their carts for 'odds and ends' they find worth keeping as they collect from house to house, and behind them, fixed into the soft slope of the ash mountain, some eight 'kettles,' or metal receptacles for the separated miscellanies with which they are gradually filled. The ashes fall at their feet, and gradually bury them above their knees. Following the sifting comes the hand-picking of all left in the sieves. Into one basket is thrown the 'soft core,' which comprises vegetable refuse, hay, straw, shavings, pieces of carpet and matting, coarse feathers, and all putrifying substances. The 'hard core,' which is thrown into another, comprises broken earthenware of all kinds, oyster shells, clinkers, rubble, and other hard worthless substances. The cinders, which go by the name of 'breeze,' after other things have been picked out, go into the third basket. The three items just mentioned become the property of the contractor or owner of the yard, and the baskets are emptied from time to time on their respective mountains in different parts of the yard, while the ash mountain gradually increases in bulk and height as the ashes are shovelled up by the men. The 'kettles' behind the sifters receive their several commodities — namely, paper, rags, bones, white glass, dark glass, iron, metal, brass and tin, corks and string, respectively. With quick and unerring hands the women throw these severally from the sieves into the proper receptacle, with as few mistakes as a compositor 'at ease,' taking his type from the several unlettered compartments before him almost by instinct, and apparently without using his eyes. These miscellaneous articles are the property of the sub-contractor or 'moulder,' and are carried off as occasion requires to his store-house in the yard, where they form large heaps divided one from another, to be sold to, and fetched away by, those who deal in such goods. Such is the separative and discriminating process to which the contents of our

dust-bins are carefully subjected to be utilised in various ways, re-made, re-formed, and in their original or modified forms to be re-issued and re-used.

"But let us again observe the chief actors in this representation—old, middle-aged, and young women, and girls. Covered from head to foot with dust, which after a shower is exchanged for paste, they present a most deplorable appearance. Some few are the happy possessors of boots which reach above the knee; others are armed below with substantial gaiters; but the majority are content with sackcloth or matting bound round their legs with string. A thick padded leather apron protects them from the jarring of the sieve, which they generally work forwards and backwards, and not sideways, as the exertion is considerably less by the former method. It would be impossible to describe their dress. All that can be said about it is that it is a covering. Material, pattern, and even make is hopelessly obscured. The headdress seems to become one with the head or hair, almalgamated as they are by the thick deposit of dirt. Their faces and arms, in the case of those who work with the latter bare, vie with those of the coalheaver or chimney-sweep — we cannot say outshine them, as the dirt on the sifters' faces takes no polish or uniformity, but settles in drifts and ridges according to the elevations and depressions of the 'human face divine.' In a cloud of dust almost obscured from mortal ken, like the goddesses of old enshrouded in cloud on Olympus' heights, some laughing, some singing, some talking, some smoking, some swearing (like the goddesses of old), they do their daily work to earn their daily bread; and after all not nearly so wretched or underpaid, and very far from so unhealthy, as might be supposed, and consequently not nearly such objects for pity as perhaps we might make them, if our object were merely a sensational description (so much in vogue), and not a truthful account, which any one not too squeamish for such investigation can easily verify.

"Let us look then, first, to their labour and earnings. The former cannot be called severe in itself, nor the hours excessive, as they begin work at seven and 'knock off' at five, having one hour for dinner in the middle of the day. This makes nine hours, but in three winter months they

work about two hours less. As to their earnings, as in many other trades, there is some little difficulty in arriving accurately at the truth, the employers being naturally disposed to represent their treatment of the employed in the best possible light, whereas the employed are inclined to put their case in a way most favourable to elicit pity. In some yards the work is done by the piece, in others by the day; but it may be considered that, taking the average of yards throughout the year, a woman's earnings are from 8*s.* to 10*s.* a week, and sometimes more when they work overtime. This includes the value of the fuel allowed them, which varies somewhat in different yards. In Messrs. Burton's yard, in Commercial Street, Lambeth, where all the City dust is delivered, and which is perhaps the largest yard in the metropolis, the women get 1*s.* per day, and a 'sider' of 'breeze,' with some wood each when they leave work in the evening. As they take care to get good measure and well pressed, this 'sider' of 'breeze' at the lowest calculation is worth 6*d.* Little markets are held generally near the entrances of the yards when the women come out with their fuel in the evening, and the poor of the neighbourhood are ready to buy it 'at a price' which suits both parties, especially the good ladies from the yard, who in retailing their fuel can easily convert their well-pressed 'sider,' or bushel into two bushels, and even then leave enough for home consumption. The scene outside the gates at these fuel markets is with a little effort of the imagination almost picturesque, and even touching, when stalwart but 'pious' costermongers' sons bring, as they often do, their barrows to carry home their mothers' portions. That the proceeds of this fuel is often converted into beer and gin is unfortunately true, but this does not alter the fact that it is worth a definite sum of money readily obtained, and therefore can hardly be considered of the nature of payment in kind. As to the health of those engaged in this business, strange as it may seem, it is most excellent, and very far above the average of the ordinary working poor. We have it on the best information that during the last cholera outbreak and the late small-pox invasion, not a single case occurred among the workers in the City sewers yard, or in the adjoining one of Messrs. Easton. This is a staggering fact; and though we do not

wish it to be taken as an encouragement of hygienic heresy, it must remain on record for what it is worth. In cholera and fever panics we are told that the dust-bin is one of the chief breeders of pestilence and the very home of fever, and that even to have them disturbed endangers the health of the inmates of the house to which they belong; and yet the men who do disturb it and cart it to these yards, and the men, women, and girls who for ten hours a day during the sifting process live in and breathe an atmosphere of it, are as healthy as, and even healthier than, the majority of the London poor; and this without wearing metal or lint respirators which an eminent physician recommends as necessary to intercept the floating particles or seeds of disease in atmospheres where their presence may be suspected. Local inspectors of nuisances and medical men, and dwellers in houses contiguous to these yards, will almost unanimously testify to these facts; and the sifters themselves seem proud in affirming the healthiness of their occupation. It might be said in the words of Shirley that 'they blossom in the dust,' and one has only to 'interview' a venerable lady who has worked at the City yard for more than thirty-five years, as a specimen of a 'good life' and good health. 'Old Betty' avers she has not had a day's illness 'since in the yard she has been,' with the exception of temporary indisposition occasioned by too free a use of the 'red stuff,' which in this establishment, where it is apparently the favourite stimulant, is the periphrasis for rum. Here, too, may be seen a splendid specimen of female humanity in the august person of the 'moulder's' lady, who we hope will pardon the liberty we take in immortalising her *personnel* in the diurnal history of the age. In her early womanhood she 'sifted' in this yard, but now has risen to the pinnacle of the dust-heap, and daily presides over the busy scene as 'mouldcress.' 'Fat, fair, and forty,' turning the scale easily at 16 stone, she is the very picture of robust health and energetic happiness, the very dust of which she takes her daily share hardly concealing her rosy cheeks, which assert themselves through it as the sun through a London fog. Such a woman, if seen on a village green in Loomshire, would be pointed at as a specimen of what pure country air will do for the human frame, and of what bloom fresh breezes

can deposit on rustic cheeks—and yet she lives and moves and has her being among dust and ashes. She evidently takes a pride in her yard, and an interest in the well-being of her workpeople, whom we hope may long enjoy her gentle but withal firm sway. Perhaps the secret of the good health of these sifters consists in their having daily a large amount of air, such as it is, and exercise; but more particularly in the fact that, from the very nature of their occupation, they are obliged every evening to change their working-clothes, and perform a thorough ablution with soap and water, articles which we fear many thousands of poor men and women, both in town and country, seldom use with a view to personal cleanliness, except for an hebdomadal washing on the sabbath, and not always then. But these girls and women, at least the great majority of them, thoroughly 'clean themselves,' as our domestic servants say, after work, thus getting 'beauty for ashes,' and those who live in the vicinity of the yards may be distinguished on Sundays and week-day evenings from their poor neighbours by their cleanliness and superior tidiness, if not elegance of toilet. The married women also, who form the majority of workers in these yards, and are generally dustmen's wives, are known to take great pride in their humble dwellings, the interiors of which frequently show a marked contrast to the untidiness and squallor of others around them. Taking all things into consideration, the condition of the 'poor sifters' is, as we have intimated, not nearly so bad as might be supposed. They have fair wages, as the times go, for unskilled labour, their hours of work are not excessive, and their health is excellent. These circumstances will compare very favourably with those of many other classes of poor workers in London—the needlewomen, for instance, who almost starve on '1000 stitches for a penny,' and whose work is most injurious to health, as their feeble forms and pallid faces sadly testify. The dust-yards are popular with the poor, and the best-conducted of them have no difficulty in finding hands; but as in all other trades, they vary in repute among those who work in them, and many of the sifters, as is the case with persons following other callings, move about from yard to yard, partly from the love of change, and partly in the hope of bettering them-

selves. In some the 'moulders' have a bad name, and are alleged to be most grinding towards the employed, and cruel in their treatment; but this may, and unfortunately does, happen in many trades. 'Moulders,' like other masters, will vary in their treatment of the poor under them.

"That the sifters are so wretchedly poor in some yards that, as has been alleged, they are glad to eat the garbage they pick out of their sieves, is hardly to be believed; and the report probably had its origin in the fact that large quantities of fish, especially herrings, are sometimes found in the carts which bring the refuse from the neighbourhood of fish-markets and from fishmongers' shops, and that some has occasionally been picked out and put aside in the hope that it might be turned to account.

"The 'findings' of money and other valuables are not so frequent as might be supposed. The men who collect the dust from the houses have the first chance, and naturally 'keep their eye' on it as they fill and empty their baskets, and occasionally are rewarded by a lucky find of money and jewellery, of which it can hardly be expected they invariably inform the householder. The chances of the fillers and sifters are consequently diminished, but copper, silver, gold, and other valuable articles, are found from time to time, but hardly sufficiently often to make it a calculation in their weekly earnings. Still, expectation and sweet hope help to cheer the hours of work, and sometimes a sovereign, or half-sovereign, or gold ring, rewards their watchfulness.

"The 'moulders' used to claim the valuables found, and endeavoured to watch the sifters secreting them; but, as might reasonably be expected, the attempt was almost useless, and not worth the anxiety, and hence the rule which now obtains is, according to the schoolboys' saying, 'Findings—keepings;' but if owners come to the yards to claim any special property it is given up to them. This was lately the case at one of these establishments, where a bag of sovereigns and a packet of bank-notes were found among the dust. A silver watch and two diamond rings were lately found at another, and the fortunate finders converted them into money, and 'no questions asked.' Still, the 'finds' of valuable 'waifs and strays' are inconsiderable,

and we imagine that the swill-tub in a country house would generally yield better than an urban dust-bin, as silver spoons and forks frequently find their way into the former, and being about the only articles, with the exception of egg-shells and squeezed lemons, which the omnivorous pig declines to eat, they may fortunately be recovered.

"One word in conclusion as to the mercantile aspect of these yards. The 'moulder' or sub-contractor, as we have said, is paid for sifting the dust about 8*d.* per load; but he has to pay the sifters, and, to cover this and other expenses, the bones, rags, &c., from the eight 'kettles' are his property. His profits will, of course, vary with the demand for his several commodities. At present the demand for rags and old paper to be again made up is very great, and they, consequently, command good prices. The City dust, as might be expected, is richer in this latter material than that from other quarters. The owner of the yard, or 'contractor-in-chief,' has the sifted ashes, cinders, or 'breeze,' the 'hard core,' and 'soft core.' The two former are sold to the brick-makers, but, as the building trade has been very dull for some time past they now only fetch about 2*s.* to 2*s.* 6*d.* per chaldron, but some years ago they were four to five times the present price. The 'hard core' is used for road-making and filling up holes, and some years ago would command a fair price, but now it is frequently unsaleable, and the contractor has to pay to have it fetched away. The 'soft core' is mixed with the road scrapings, or 'slop,' as they are called in the trade, in about equal proportions, and with a third of pure manure forms the first-class 'mixture' which is used for agricultural purposes. Mixtures with less or no manure at all are of less value, and made up to order and priced as the buyer gives instructions. As many as 700 cartloads per week of all sorts is delivered in the City yard, and almost as much in some others. This is the prose of the matter; whatever poetry it contains is contributed by the lady sifters and their work."

Old Railroad and other Iron.—A trade has sprung up of late years to which the iron merchants and manufacturers of the past were total strangers, and the magnitude of which would surprise those unacquainted with it. Large imports of old rails are received in the United States, principally from Eng-

land, although occasionally cargoes are received from the Continental ports, and a few from the West India Islands and South America. To such an extent has the trade increased, that the demand is far in advance of the supply, and sales are made almost altogether to arrive. The advantages possessed by this form of iron for entering into new manufactures are, convenience of form and shape for piling and heating, superiority of metal from the constant impact of heavy weights to which it has been subjected, and the facility of working with new iron under less manipulation. It is not surprising, therefore, that we find cargoes of old rails transported across the Atlantic by vessel, and thence over the Alleghanies by car to Pennsylvania for the rail mills of Pittsburg, or Johnstown, or Danville, where they again enter into the same uses for which the iron was first designed, and, Phœnix-like, rising from their ashes to a new life. Old rails are also largely used by the railroad spike and bolt makers, and by the manufacturers of fish-plates and bars.

Manufacturers should look well to their scrap iron. Do not waste a piece, no matter how small; gather all together, assort, have different receptacles for steel, wrought, cast, and malleable iron. The wrought iron from the carriage shop is the most valuable of scrap iron, but to bring the highest price there must be no malleable or cast iron mixed with it; every pound of scrap has a market value, and it should be packed in barrels or boxes and sent to market. If there be any considerable quantity, it will pay to send it to the mills and have it worked up into bars. It is the small manufacturers who do not take care of their scrap, but allow year after year to pass without paying any attention to it, and scraps of iron can be found all over their factories, while boxes and out-of-the-way corners are filled with it, and many tons of what would make the best of bar iron is allowed to go to waste.

Scrap iron, such as the cuttings and parings of iron-work, is collected and melted again in the puddling furnaces. Some of the inferior articles rolled from scrap iron, such as axles, owe that inferiority to the careless manner in which the "piles" are made up, by children and persons entirely ignorant of the peculiar properties of iron and steel. At the works where this scrap is used, some of the

softest and toughest iron, bolts, wire, hoop-iron, old files, axes, saws, &c., are indiscriminately mixed together. To a certain extent, each of these qualities has its peculiar welding point. When worked together, one portion that is less refined is too much heated, and consequently deteriorated, before the more highly refined portions have reached a welding heat, and we are thus placed in the awkward dilemma of either burning the one or being unable to weld the other. In the best-managed mills the selection and piling of scrap iron for axles is intrusted only to "experts," or those who have had long experience in the selection and working of metals; and car axles made at these establishments have a reputation, and stand tests both theoretical and practical, such as show that this discrimination in selection of the material is a perfectly practical matter. When the selection is left, however, to the careless and incapable, the imperfections in piling become a sure source of danger and disaster.

It is well known that the more frequently old wrought iron is worked over the better it becomes. Acting upon this principle, all the axles with worn journals on the Central Pacific Railroad are now sent to the shops in Sacramento, and by a blow of the trip hammer the ends are cut off. These ends are thrown into the scrap pile and are worked over as needed. The amputated axle is now upset and the ends beaten out to a shape like a hollowed hand. Into this hollow a fifty-pound piece of fresh iron, at white heat, is welded and thoroughly worked upon the axle, which, being re-turned in the lathe, is found to be superior in all respects to completely new axles. Since this plan has been adopted over ten thousand journals have been thus treated.

An order has been lately promulgated to the effect that all old anchors and chain cables delivered to the receivers of wrecks, when deemed useful for other purposes, shall be tested when convenient; and those chain cables and anchors that stand the test are to be sold, but the rejected materials are to be disposed of as old iron. In the case of anchors and chain cables not being sufficiently good and very old, and no test-house handy, one arm of the anchor is to be broken off, or the shank to be broken through: and chain cables are to be cut, so that they may be sold in

lengths not greater than 7½ fathoms each, and then they are to be sold as old iron.

Any one visiting the large docks of London will occasionally see large loads of old iron being shipped as dunnage or ballast in vessels bound for the United States or for the Continent. It comprises a heterogeneous collection of all descriptions of articles, frying-pans and gridirons, saucepans and candlesticks, tea-trays and boilers, shovels and old corrugated roofing; and many are the jokes of the men who bundle this old iron into the ship's hold. It is the accumulated produce of the old-iron shops, the collection of the "mud-larks" of the rivers and other itinerants.

In 1857 we exported only 36,500 tons of old and broken iron, but of late years this quantity has more than trebled, and the value is enhanced by the high price of iron. The exports and value of old iron were in

	Tons.	Value.
1870	106,749	£501,536
1871	139,812	672,696
1872	108,181	661,931

It is a great mistake to suppose that iron made from scraps will possess a toughness superior to that which it originally possessed. Blows and concussion tend rather to disintegrate than to toughen iron unless these blows are received when it is heated to the proper temperature. The material for horse-shoes and horse-shoe nails is made of the best and most fibrous iron. The scraps, therefore, possess a higher value than scraps of other kinds of iron, but they get no value whatever from their use.

Gunmakers tell us that no iron is so well fitted for their purpose as that which is derived from horse-shoe nails and similar worn fragments. The scrap iron from needle-making and other manufactures is sold by cart-loads for making gun-barrels, as it is the finest-tempered steel. The waste metal in cutting up steel pens in Birmingham is returned to the Sheffield steel converter, to be worked up again, an allowance being made for it of £10 per ton, the original cost being £50 or £60 per ton. Steel-filings are sought for by the chemist to make steel wine.

Old type-metal is bought up to be re-cast. And a monument erected to the memory of Horace Greeley, the founder

of the 'New York Tribune,' is formed of many thousands of pounds of old type contributed by printers in the United States for the purpose.

Few persons have any idea of the enormous quantity of steel hoop and wire manufactured for the millions of crinolines used, and as fashion gradually changes, the utilisation of these cast-off hoops becomes of consequence. Thousands of these are said to be thrown into the streets of New York and other large American cities, where they are a nuisance and a plague to passengers. The *chiffoniers* utterly reject them, as not worth picking up, and the dustmen do not like them, as they are not very portable. A witty journalist suggests that they might be used with a pole in the centre for a rosery or trellis-work in gardens. At any rate some plan should be adopted to utilise this great waste of steel in cities, so that old crinolines may be gathered with as much avidity as old rags and papers are now.

At a meeting of the district association of German engineers on the Leune, at Lethmate, in August 1871, Mr. Kugel explained a simple process adopted by him for obtaining green vitriol as a by-product in ironware manufactories which use acids, and have to neutralise the same for sanitary reasons before they are discharged.

Instead of the costly leaden vessels, such as are employed on a large scale and in great numbers in vitriol factories, he takes a cast-iron pot, about 1 inch thick, 4 feet high and the same in breadth, containing about 40 cubic feet, which, after being in use for two years, was not corroded away to the extent of one eighth of an inch. Under this he places a furnace of one square foot heating surface. The pot can be charged afresh every day; the evaporation takes nearly ten hours; some iron shavings placed in the vessel serve to neutralise any free acids that may be contained in the raw liquids as produced in the manufacture. In wire factories the acid solution generally stands at 26° Baumé, and must be boiled down to about 40° Baumé.

A discharge pipe, placed a few inches above the bottom, conveys the concentrated liquor into old oil-casks for crystallisation. For facilitating crystallisation, stout strings or iron wires are suspended in the liquor. About two-thirds of the quantity of green vitriol contained in the fluid is

thus got as a crystallised mass. To obtain 600 lbs. of copperas by this process, about 360 lbs. of coal are required. One man is sufficient to attend to the apparatus. The mother liquor of 24° Baumé, running from the crystallisation vessels into a vessel let into the ground is pumped up again by a lead pump into the evaporating boiler, and again boiled down to 40° Baumé.

In many ironware manufactories no sulphuric acid is used, but spirits of salt; the result will then be a muriate of iron, and not copperas.

Cinders from fineries, puddling and reheating furnaces, and scale from rollers, squeezers and hammers, contain from 40 to 70 per cent. of iron in globules of various sizes dispersed through them. These cinders and scales are equal to 30 or 40 per cent. of the iron turned out. It thus appears that the iron wasted in the cinders is no less than from 12 to 28 per cent. as compared with the iron that is utilised.

The proposal to give a more practical use to the many thousands of tons of cinders that are drawn from the puddling and heating furnaces, and which are by most of the rolling mills thrown away as useless, or, in the best case, used up as admixture to iron ores in blast furnaces, in order to increase the quantity (but certainly not to improve the quality) of the iron, has occupied attention for some years past. Mr. A. L. Fleury made numerous experiments on a practical working scale. Chemical analysis showed that these cinders contain invariably from 25 to 50 per cent. of metallic iron, combined and mixed with sulphur, silica, lime and alumina, forming a brittle compound of a very peculiar construction, defying the most ingenious devices of the ironmasters. Mr. Fleury states that at Troy, New York, near the Troy and Albany Ironworks, are many thousand tons of these puddling cinders spread over the streets, every hundred pounds of which contain from thirty to thirty-five pounds of good iron. After many unsuccessful attempts, he succeeded in extracting good cast as well as wrought iron, and was even so fortunate as to produce from this refuse material a good quantity of cast steel. Two great difficulties had to be overcome; first, the oxides and metallic iron are in these cinders combined with silica and other substances in such a peculiar way, that, by re-

melting the same in the puddling, cupola, or other furnaces, very little of the metallic iron can be extracted, the combination withstanding even the high heat in a steel crucible. No sufficient percentage of iron can be extracted to make it pay. Secondly, it was found that by re-working the cinders with lime alone, or with lime mixed with charcoal and clay, the product was invariably red-short, and many times red and cold-short (brittle at a bright red heat, as well as when hammered cold). The sulphur remained still combined with the iron, equally so the silica and phosphorus—the three devils or evil spirits of iron. All attempts to extract good neutral iron from the puddling cinders by dry admixture of lime were unsuccessful: there was no other way open but to destroy or loose the tenacious chemical combination of these substances before they were placed into the furnace. Unslaked burnt lime has the peculiar property to decompose silicates during the act of hydration, or slaking, as it is commonly called. This can be easily demonstrated by pouring water slowly into an intimate mixture of sand and fresh-burnt lime: the outside of the sand grains will yield to the lime's gelatinous silica, and, when mixed, form with it a strong chemical combination, silicate of lime—the base of a good mortar. Taking advantage of this chemical fact, Mr. Fleury mixed a proper percentage of powdered burnt lime with the fine ground cinder, and after wetting the whole with water, exposed the mixture to the drying influence of the atmosphere. The dry compound was then heated in a common puddling furnace, and treated like pig iron. He obtained 50 per cent. of wrought iron, which, however, retained still some traces of sulphur, leaving the iron somewhat red-short. To extract these last traces of sulphur he dissolved in the water, which he used for slacking the lime, a small percentage of a chlorine salt, and his expectations were thoroughly realised. The process is also applicable to the working of silicious ores, and can be performed in the puddling, cupola, or blast furnace; it can also be worked to advantage in Bessemer's, Nystrom's, Swett's, and other similar furnaces. The preparation of the cinder, cost of lime, salt, &c., does not exceed two dollars per ton, and the result is, if properly worked, invariably a good quality of iron.

Messrs. Minary and Sondry, France, have adopted a process which may be thus summarised :—

In attempting to utilise cinder, iron-makers have hitherto treated it as an ordinary ore, and charged it at the mouth of the blast furnace without preparation except breaking it into lumps. But whatever may be the quality of the ores and the care taken in the composition of the charge, the proportion of cinder used in this way is limited, and the least excess deranges the working of the furnace. Consequently those who make superior pig iron have given up the use of cinders. In all cases where grey pig and foundry pig is to be made, cinders have to be excluded, as they whiten the iron. Now, if we consider the nature of the cinder and the action of the blast furnace, we see that this furnace does not possess the conditions requisite for the treatment of cinder ores.

Cinder is a silicate of protoxide of iron, of variable composition, fusible at 900° ; therefore, when in the blast furnace, it melts rapidly, runs through the ore with which it is mixed, and passes through the successive zones of the furnace without having time to be reacted upon by the gases. In this state the cinder arrives at the point where the iron is in fusion, a few inches above the tuyères, where a portion of it, which is thus finally lost, is taken up by the normal slag, which thus becomes charged with silica and protoxide of iron, and consequently highly decarburising. The remaining portion of the cinder is decomposed, the pig metal taking up the oxide of iron it contains, also the silicon, phosphorus, and other impurities which have accumulated in it in the various processes of its formation. Under these conditions the product of the blast furnace consists of a mixture of oxide of iron and of pig metal partly decarburised by the abnormal slag which results from the combination of the unreduced cinder and the normal slag. This pig metal is always white, silicious, and of inferior quality.

On examination of the cinder, we find that the silicates of protoxide of iron of which it consists are reducible by carbon at a red heat. But in the blast furnace there is no moderate heat and no prolonged contact with the reducing agent; but, on the contrary, a rapid descent through the ores of the furnace to the fusing-point of the pig iron,

where it produces harm, as we have stated. Besides, at this high heat, and in the presence of iron and carbon, the silica, which, by itself, has no affinity for iron, is decomposed, yielding silicon, which alloys the pig metal. Thus the pig iron becomes silicious in proportion to the quantity of raw cinder put into the furnace: and the sulphur, phosphorus, and other impurities likewise pass into the pig iron.

To reduce the cinder completely, it is necessary to keep it long in contact with the fuel, and that the heat shall be moderate. This double condition is fulfilled in coke ovens, the gases from which are usually wasted. Coke cinders can be made in these ovens, by mixing coal and cinder, both pulverised, and coking in the usual way. The decomposition of the cinder occurs at a dull red heat. The oxides of iron yield their oxygen to the carbureted hydrogen gas; the operation is slow, the reduction is complete, and the reduced iron already shows a commencement of carburisation. The conditions most favourable to these two reactions of reduction and carburisation are here combined: the prolonged contact of the iron with the carbon in an atmosphere essentially reducing, and the presence of iron, in a nascent state, with bicarburetted hydrogen, which is the most highly carburising agent known. These reactions are effected in coke ovens, at a temperature too low for the decomposition of silica, and consequently for the production of silicon; so that the silica, not being changed, remains without action on the iron. The contrary occurs in the blast furnace, where the partial reduction of the cinder takes place close above the tuyères, where the heat produces silicon, which is absorbed by the iron.

Analyses show that the greater part of the phosphorus and sulphur in the cinder are carried off by the carburetted hydrogen, in the states of phosphoreted and sulphuretted hydrogen.

The coal and cinders have to be mixed in different proportions, according as the coal is more or less coking, in order to make a strong hard coke, or coke-cinder. Good results have been attained with 40 of cinder to 60 of average coking coal. This coke-cinder contains free silica with coke and carbonised iron mixed throughout the mass in minute subdivision, and is a fuel containing 20 to 25 per cent. of carbonised iron.

In the blast furnace this coke-cinder acts like common coke; it suffers no change until it reaches the zone where the carbonic acid formed about the tuyères is transformed into oxide of carbon by contact with it, taking up its second equivalent of carbon. The carbonisation being complete, the iron collects in small drops, and runs off before the more refractory silica which accompanies it passes into the slag, by which it is carried off from the furnace. Of course the charge must be so composed that the silica may have the elements necessary to turn it into slag.

Besides utilising a rich ore, hitherto little used, this process economises fuel and improves the iron.

Messrs. Bond, Russell, and Co., of Newport, Monmouth, in 1866, made some experiments on the refuse from iron furnaces, and, finding that it possesses the property of emery, patented the discovery.

A Bohemian engineer proposes to economise the waste phosphorus of iron ores by converting it into soluble salts. He accomplishes this result by acting on the stamped ores by sulphurous acid, thus rendering the phosphorus soluble. The ore is then thoroughly leached by water, the excess of sulphurous acid expelled by heat, and quick-lime added until the whole of the phosphorus is precipitated. The precipitate can be used at once for agricultural purposes, or can be worked up into salts of phosphorus. Where sulphur ores are used, they can be roasted, and the sulphurous acid thus evolved advantageously economised to convert the phosphorus into the soluble modification. The iron ore, freed of its phosphorus, is now in condition to be worked for pure metal. The process can only be available where labour is cheap and good iron scarce, and where the yield of phosphoric acid would pay for the cost of its separation. The use of sulphurous acid for the purpose of reclaiming phosphorus ought to receive more attention from our metallurgists and chemists.

Dr. T. Anderson says: "Many of the suggestions which have been made regarding the use of refuse matters are of a singularly unpractical kind. Mr. Melvin, for instance, mentions in one of his letters that in the ironworks a quantity of ammonia is lost, which, if collected, would not

only supply our home demand, but admit of large exports. This, however, is only true in the sense that when coal is burnt ammonia is always set free and lost. If the coal now burnt in the ironworks could be distilled as it is in the gasworks, all this ammonia would be saved; but it is unnecessary to say that this would be incompatible with the use of the coal as fuel, and I fear we must be content to allow the ammonia to go to waste. Some years ago it was also announced that potash existed as a waste in one of the operations of the ironworks, and newspaper paragraphs dilated on the importance of the discovery to agriculture; but it was soon found that the quantity was small, and could be obtained only at intervals and with some difficulty, and I need scarcely say that no effect has been produced by it."

In the manufacture of galvanised iron a considerable quantity of either muriate of ammonia or sal ammoniac is used, the same being thrown upon the molten zinc; in a short time a dirty mass is produced, consisting mainly of chloride of zinc, oxide and carbonate of zinc, a little metallic zinc, and occasionally a trace of muriate of ammonia. This mixture was formerly of little use, and sold at a cheap rate mainly for reconversion into metallic zinc, being generally known either as waste or spent flux. To utilise this material, Mr. J. Webster patented an invention in 1863, according to which he takes any given quantity of spent flux and macerates it in water for a convenient period, and when most of the chloride of zinc has dissolved he stirs up the solution, which causes the lighter particles of oxide or carbonate of zinc to be held in suspension in the liquor; he then draws this solution through a suitable strainer into a tank standing at a lower level, and, if necessary, repeats the process until the greater part of the chloride of zinc has become dissolved and run into the second tank. The fine particles of oxide or carbonate of zinc held in suspension in the solution in the second tank he allows to settle down, and draws off the supernatant liquor containing the chloride of zinc into a third tank, and then washes the precipitate in the second tank, and again runs the liquor into the third tank. The liquid in the third tank he now treats with ammoniacal liquor, such as the

refuse of liquor from gasworks, which causes a precipitate of oxide of zinc, and leaves a solution of muriate of ammonia; this solution, when evaporated and crystallised in the ordinary way, may be used in the galvanising works, or disposed of elsewhere. The precipitate left in the first tank would find a ready market among the refiners or others, at a higher price than the original spent flux; and the precipitate in the second and third tanks is, when properly dealt with, very suitable for paint.

Old copper sheathing, taken from ships' bottoms, copper bolts, &c., are always very saleable for reconversion. The barrels of brass filings are generally saved in the Birmingham workshops, fetching about half the original cost of the metal.

Copper garment rollers, used in the engraving trade for calico printing, &c.—These metal cylinders, when at first supplied by the copper founder, are very heavy. As the necessity for a fresh pattern arises, the old roller is put on a turning-off lathe, and a new plain surface made upon it to receive the next design. Rollers can be engraved time after time on these new surfaces, until they are worked down to a substance of only one-fourth of an inch. The shavings which are turned off the old rollers from time to time have of course a market value, and are treasured in barrels and sold to the manufacturers. The price obtained for them varies with the rise and fall of copper; when copper is at 1*s.* 2*d.* per lb., they fetch about 9½*d.* Usually about 2 lbs. are turned off a garment roller at a time. The roller has then to be polished with two or three kinds of polishing stone. It can easily be imagined that, if the copper turnings are valuable, a certain value must attach to the slime which is found in the polishing troughs. This is worth somewhere about £8 10*s.* per ton, and when assayed it is generally found to contain about 24 per cent. of copper. The usual way of disposing of this polishing slotch is to barter it for new polishing stones.

The value of glass having gone up very much lately, glass bottles are always a saleable article at the bottle warehouses and the rag shops, wine and soda-water bottles fetching about 9*d.* to 1*s.* a dozen. Flint glass is also sale-

able, being worked up again; and I am informed that there are from 1000 to 1200 tons of cullet, or broken glass, bought and used up annually in the few glass-works of the metropolis alone.

Mr. Daniel W. Hanna, of Pittsburg, Pennsylvania, took out a patent in October, 1871, for a method of utilising the waste chloride of zinc in treating paper; and Mr. R. J. Jones, of Ellerslie House, Walton, Liverpool, has patented improvements in operations and apparatus for drying down waste alkaline solutions of extractive matter obtained in preparing vegetable fibrous material for use in the manufacture of paper, and in recovering therefrom the alkali for re-use; also for utilising the vapours given off during the boiling of the vegetable material, or the drying down of the said solutions.

Economical Uses of Furnace Slag.—In travelling through the iron districts of England, it is imposible to avoid being struck with the vastness of the works carried on in those places. A journey through our mining districts—where undying flames leap forth from hundreds of volcanoes, and around which nothing is discoverable but blackened piles of cinders and unsightly slag—will not be easily forgotten. For scores and scores of miles, the traveller beholds these apparently interminable heaps of refuse ore. Carts, waggons, and trucks may be seen on all sides, occupied in the endless task of removing this metallic encumbrance of the smelting works. Hundreds of labourers are engaged in conveying to remote and undisturbed spots the enormous piles of black, friable, clinkery-looking stuff—the slag that day by day and hour by hour is produced by the smelters of iron ore. Some is flung down deep gullies, and hidden in the dark yawning recesses of ravines, when haply any such are to be found. Some is employed in the hardening of rotten roadways, where it is made to perform a very unsatisfactory sort of duty for stone. Occasionally it is shot into the sea, when near enough for that purpose, which, however, is not often the case.

Of the actual extent of this rubbish production some idea may be formed, when it is stated, as it has been, on very good authority, that in the removal of all this waste slag from the furnace-mouths of the United Kingdom, not

much less than half-a-million sterling is annually expended. Indeed, it has been calculated that in round numbers there are, at the present time, fully six millions of tons of this refuse material produced in one year. At this rate it would be easy to imagine the gullies, pits, and ravines of the iron districts becoming filled up at no very remote period, when iron-masters would have to go farther in search of secluded spots whereon rubbish might be shot.

Every ton of iron smelted produces a ton and a-half of slag or cinder, and the aggregate quantity of this mineral, capable of use as a substitute for stone, in any iron-making country, must be immense. At Barrow-in-Furness, England, about nineteen million tons of slag have been produced during the last twenty years. This is equal to about eight million cubic yards; enough to have built six pyramids the size of Cheops, or to have covered five square miles to a depth of ten feet. It has there been used for reclamations, filling up sunken lots, &c., and for the building of a sea-wall, and similar works. Among other undertakings in which the use of the material has played a prominent part, has been the enclosure of a square mile of land, which (the sea being shut out) is to be utilised for building purposes.

The mode of using this substitute for stone is not always, as might at first be supposed, the laying of symmetrical blocks in regular order, but, from the descriptions given, it appears to be thrown pell-mell, and to form rather a rip-rap than a firmly-laid mass of stony material. The slag is run in small streams from the furnace to rude moulds formed by the slag waggons, which, cooling rapidly, are full of fissures that cause them to break easily, and this would prevent their adoption as sub stitutes for brick or shaped stone, unless some means were applied to secure greater homogeneity and hardness—a thing of apparently easy accomplishment. It is stated that this is done in some of the iron manufacturing districts of France and Belgium, and that buildings and street pavements are made of the artificial porphyry, for it is nothing more, from the blast furnaces. Several methods were proposed some years ago by Bessemer and others, for casting, annealing, and shaping slag for various pur-

poses, and in view of the immense quantities of this now waste material, it would be well if these, or some other methods, were at least tried, to practically test, in iron-producing countries, the feasibility of adding a new material to the by no means extensive list of those now commonly available to the engineer and architect.

Messrs. Sepulchre and Ohressen have perfectly succeeded in utilising the slag of the iron blast-furnaces for the manufacture of paving stones for the streets of Metz, Brussels, and Paris, and they have stood heavy traffic far better than even the celebrated Quenast stones. One great advantage is that it does not become polished by use. The streets paved with this material at Brussels have a heavy gradient. In England it is not likely to compete with good paving stone.

Dr. Paul, in a paper "On Useful Applications of Slag from Iron Smelting," after observing that slag was of a nature between porcelain and glass, stated that it was proposed at the present time to convert it into bricks for building. This was done by a simple and ingenious contrivance. A gentleman had succeeded in blowing the slag into a state of very fine division, by sending steam or air into it, just as it flowed from the blast furnace in the liquid state. It was thus blown into a substance resembling wool in appearance. This substance was taken and ground into dust, mixed with lime, subjected to powerful pressure, and made into bricks which require no fire. After being pressed they were allowed to dry, and could be used at once, the influence of the atmosphere producing a slow kind of hardening. It was also intended to use the powder as a manure.

Blast-furnace slags are granulated at Osnabruck, Germany, by allowing the molten stream from the tap to flow into water from a suitable height in the same way as lead is converted into shot in towers. The slag is used for filling in between railroad sleepers, and also in the manufacture of concrete, and if it contains considerable alumina is ground and converted into alum.

Mr. T. Egleston, in 1872, read before the American Institute of Mining Engineers a paper full of valuable information on the uses of blast-furnace slag, and described a process by which good bricks may be made of it,

and he stated that bricks could be formed of it and a cement made equal to the best Portland, at a small cost.

By blowing steam into the molten scoriæ, filaments are produced, to which the name of mineral cotton has been given. It is proposed to use this for steam-jacketing purposes, as it has the advantage of being non-inflammable.

In 1867 the Belgian State railways contracted for the supply of 100,000 paving-stones of slag or artificial porphyry at the rate of 102 to 104½ francs per 1000. The ordinary Belgian paving-stones of chloritiferous porphyry of Lessures, &c., were then selling at 115 to 134 francs per 1000.

Some little attention has been directed of late in France to a method of treating furnace slag so as to obtain an artificial porphyry. To this end furrows are dug in the slag pit in the form of an inverted truncated cone, from 12 to 15 feet wide, so as to receive the slag from one or more furnaces at one drawing off. Into these forms the slag is conducted by suitable channels, and the mould may be divided by partitions so as to cast the mass into any desired size and form. Care must be taken to have the slag run under the thickened vitreous crust which forms at the beginning of the operation, in order to retain the heat; it often being necessary to cover the mould with ashes, to prevent the slag from cooling too rapidly, as several days are needed for this cooling, according to the amount of slag cast. When the operation is completed, dense homogeneous blocks will be found underneath the vitreous covering, closely resembling porphyry, both in character and appearance. This material has been tested by suitable methods, and found to bear a pressure of about 700 pounds to the cubic centimètre, while for complete crushing a pressure of about 1100 pounds was required. In other experiments with this artificial stone, fractures could not be produced with a less pressure than 600 pounds, while some blocks resisted a pressure of 1300 to 1400 pounds.

In Germany the economical use of iron slag has been pushed so far that there are a good many furnaces on the continent which actually sell their slag. The slags are either run directly into iron waggons or into water for granulation. They are worked up into cement and artificial

building stones, are employed in chemical processes, especially the manufacture of alum, are used to make crown glass where lime is required, and, in general, waste cinders are in Europe fast becoming a thing of the past.

All the varieties of scoriæ are not equally applicable to the manufacture; those which contain too much lime break after long contact with the air. In general those slags are best suited which contain from 38 to 44 per cent. of silica.

From experiments made at the Conservatoire des Arts et Métiers, the bricks made with slag from the furnaces where white metal is run, did not break until a pressure was applied of nearly 500 lbs. to the square centimètre, and required a pressure of 1772 lbs. to crush it. With the slag of grey metal, the crushing took place at 810 lbs., and a pressure of 500 lbs. formed fissures in the mass. This substance, therefore, is more resistant than the best marble.

A Belgian furnace which produced 2500 tons of slag in a month, furnished by this process 1177 cubic mètres of these bricks. The cost of manufacture being 4220 francs, 70 per cent. of the slag could be utilised, and sold to advantage 25 per cent. cheaper than other constructive materials.

Economical applications of what were formerly "waste products" are becoming more common every day in France and Belgium, and our neighbours bring an amount of science and practical ability to bear on such matters which deserves admiration, and should supply useful lessons to some amongst us.

Mr. Woodward, of Darlington, has patented a plan for manufacturing bricks from scoriæ, and the system is now at work at the Eston works of Mr. Thomas Vaughan. The slag is taken as it comes from the blast furnace. It runs into a series of moulds, placed at regular intervals on a revolving table. After being removed from the moulds, the bricks are thrown into a kiln or furnace close at hand, where they are annealed; and afterwards they are used in any ordinary structure for which clay bricks are suitable. The fracture is said to be close and firm, and they are capable of resisting an intense heat. So far as strength is concerned, they will withstand a crushing force of 3 to 4 tons per cubic inch, or four or five times more than that

of common bricks. It is alleged that the scoriæ brick remains unaffected by exposure to the atmosphere, but this does not accord with what has been said of slag (used for roads), which is found to contain sulphur, and to be liable to disintegration. This should be disproved, if possible, of the bricks. There is a considerable loss by breakage, but once solidified they are as hard as granite. It is calculated they can be made for 8*s*. per 1000, or even less, whereas ordinary bricks cost 20*s*. and upwards per 1000. A new company has been formed, on the limited liability principle, to work Mr. Woodward's patent, and they have acquired the right to the slag of all the blast furnaces on the Tees, including those above and below Middlesborough.

It frequently happens that there exist in the slag of high furnaces quantities of iron in a state of combination; it is therefore useful to ascertain from time to time the proportion contained. But this is rather difficult, for it very often happens that it is impossible to decompose the slag by means of acids. This is the case with crystalline slag; those of a vitreous nature are much more easily decomposed. A little vitreous slag, finely pulverised, and operated on by chloric acid, dissolves and leaves a silicious deposit, and a crystal substance. In order to decompose the slag it is advisable to use fluoride of ammonia, from the facility with which it is prepared and kept. The sample, finally pulverised, is heated in a platinum crucible, with three or four times its weight of fluoride of ammonia. Sulphuric acid is gradually added, still heating it, till the cessation of the effervescence. The crucible is heated in a sand-bath until the acid begins to volatilise; cold water is added, which dissolves the whole of the mixture with the exception of the sulphate of lime, and it is then filtered and washed until the liquor which runs off contains no more iron. This liquid is operated on by zinc in a retort so as to reduce the iron, and lastly, as usual, by permanganate of potash.

It is not easy to limit the application of this valuable rubbish. Wherever durability is required, united with peculiarity of form, there the prepared slag will be found perfectly adapted; for, inasmuch as it can be cast into moulds of any shape, all labour spent in hewing and cutting marble or stone is avoided. It is perfectly compact

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and impervious, and therefore admirably suited for the construction of aqueducts of any size. It remains unacted on by chemicals of the greatest strength, consequently it may be employed for making gas-piping, as it will last out many of the ordinary iron pipes.

When wrought in its higher character, run into suitable moulds, and polished more brilliantly than marble or porphyry, it will furnish pillars, façades, slabs, &c., for the ornamentation of mansions, halls, and public buildings, at a price and in a style not hitherto attained.

Regarding this important discovery from whatsoever point of view, whether in reference to the vast quantity of now useless refuse that may be made valuable, to the many interests that will be benefited by it—ironmasters, copper smelters, builders, architects, house decorators, and water companies—I cannot but look upon it as one of the most promising results of modern science in an age peculiarly fruitful in marvellous inventions.

New Uses for Asbestos.—Amianthus, or asbestos, is a material with which (until recently) many experiments have been made and but little accomplished. Of late years, however, its existence in large quantities in various quarters has been ascertained, and a cheap and large supply is now confidently calculated upon. The peculiar character of the substance, which, in ancient times, led to its fabrication into incombustible fabrics, fits it for many uses as yet but very imperfectly developed, while its smoothness, when finely disintegrated, has suggested its employment for some purposes for which powdered soapstone has hitherto in some cases been applied, such as the fabrication of anti-friction gaskets for packing, and the like.

Asbestos is a mineral fibre consisting of silicate of magnesia, silicate of lime, and protoxide of iron and manganese. In mineralogical parlance, it is a fibrous variety of actinolite or tremolite. Several varieties of this mineral have different names: aniout, byssolith, mountain wood, mountain cork, mountain leather, &c. They are all silicates, or compounds of silex (silicic acid), with an earthy base. The greater number of them are hydrated silicates, but all varieties are distinguished by a crystalline fibrous structure possessing a certain amount of flexibility and elasticity of

which usually the whole mass partakes as well as the single fibre. In former years, deceived by the idea that this property belonged exclusively to certain chemical combinations, the different varieties of asphaltum were supposed to be identical in elementary composition; but we know at present that the asbestos form belongs to no exclusive mineral, but is only a peculiar condition under which many minerals may present themselves. It has been agreed to apply the name "asbestos" only to those fibrous minerals possessing the chemical composition of the augit or amphibolit. The ordinary German asbestos of Tyrol is of this class; also the mountain cork of Tillerthal, and the fibrous traversilit. The fibrous amphibolit forms a kind of asbestos, to which belongs the fibrous talc of St. Gothard, the fibrous Krokydolith. In all these minerals a portion of the magnesia is displaced by basic water, and it is exactly the presence of this water which appears to give to these minerals the fibrous structure, and in general causes the crystalline structure to be found with one long axis, obliterating all sideward aggregations of molecules.

Other minerals adopting sometimes the arbert-like structure, are the serpentin and tourmalin. To this class belong the mountain wood, which is found on Staten Island, United States, and the mountain leather of the Tillerthal, Germany.

By far the most extensive deposits of this mineral at present known exist in the United States, Italy, and Corsica. Beyond central Vermont, on the eastern slope of the Green Mountains range, and in New York State, on the eastern slope of the Anderondacks, there occur some of the most remarkable and extensive formations of asbestos and amianthus at present discovered. The fibre is of extreme fineness and high tensile strength. An examination of the several varieties of asbestos appears to indicate a gradual increase in the tenacity of the fibre found in a direction proceeding from Georgia to Vermont, and this quality appears to culminate in that met with in northern Vermont. The fibre in that locality varies in length from two to forty inches; and in colour, when taken near the surface, resembles that of unbleached flax; but, as the veins are

worked into from the surface, it becomes of a pure white, endowed with great flexibility and tenacity.

Asbestos exists also in the Tyrol, Hungary, Greenland, Wales, Cornwall, Banffshire, and in the north and east of Ireland.

In appearance as friable and perishable as thistledown, asbestos is older than any order of animal or vegetable life on earth. So little amenable is it to the dissolving influences of time, that the action of unnumbered centuries, by which the hardest rocks known to geologists are worn away, has no appreciable effect on this strange substance, which is found embedded in them. With its greater proportion of bulk composed of the most rough and gritty materials known, it is itself as smooth to the touch as soap or oil, and may be made as light and buoyant as feathers. Apparently as combustible as tow, the fiercest heat cannot consume it, and the thready filaments may be mingled with molten brass or iron without losing their characteristic form. Finally, no combination of acids at present known in any way affects the appearance and strength of its fibre, even after days of exposure to their action. The name given to it is drived from the Greek. "Asbestos" literally means "indestructible"—a title which is very thoroughly earned by this strange substance. It is, moreover, so unassailable by all known solvents that it is very difficult to analyse and give its component parts with exactness. Enough, however, is known to enable us to speak of it as consisting of from 50 to 60 parts silica, 10 to 20 parts magnesia, a small proportion of alumina, some traces of protoxide of iron, and occasionally a lime-like mixture. These proportions vary greatly in the hundreds of different varieties of asbestos known, and govern and regulate exactly its value for practical purposes.

Chenevis gives the following analysis:

Silica	59
Magnesia	25
Lime	9
Alumina	3
Water, iron, loss, &c.	4
Total	100

The different analyses made by Thompson, Berthier,

Schmidt, Delesse, and others, have given almost the same result.

Asbestos is found in nearly every part of the world, and occurs in distinct veins and seams, usually in the serpentine formation of rocks. In order to procure it, it is necessary to mine in regular form, and to work the lodes or seams by blasting and tunnelling. This, in many cases, is a very costly process, as the rock in which it is found is extremely hard. The seams vary greatly in size, width, colour, and general appearance in different parts of the world. In fact, no two are exactly alike, but they have almost universally the same dip and inclination. The marvellous properties and consequent prospective value of asbestos to mankind, have been known to some extent and appreciated for thousands of years, and vast sums of money have been expended in endeavouring to make it available; but up till within a few years these experiments have for the most part resulted in failure, from the fact of the varied and dissimilar peculiarities of the different species—such, for instance, as the length, strength, and fineness of the fibre, excess of magnesia or aluminum, &c.—being unknown. Having neither experience nor theory to guide them, the experimenters have invariably misdirected their energies by using the wrong or the unselected and unprepared species for their different works, and consequently, their efforts have been unavailing. The rock upon which all have heretofore split has been the mistaken impression that all asbestos is of the same nature. This is correct in the abstract. It is true that all asbestos is extremely refractory—insensible to the action of acids, moisture, or decay. Yet it is not true that all asbestos may be treated alike, or, if treated alike, similar results will accrue. For instance, paper can be made from asbestos, and of excellent quality too. Still there is only one or at the furthest two kinds of asbestos that can be made into paper at all, and that only by proper and peculiar treatment. This also is the case as to thread and cloth, and, in fact, with reference to any and all other applications of asbestos; but, owing to the extraordinary affinity of asbestos for water, experiments in this direction are for the present in abeyance. In 1853 a patent was taken out for the preparation and use of asbestos for paper-

making. The pulp was mixed with alum, and an indestructible paper produced. The low price of this mineral, its power of resisting heat, and its low heat-conducting power, have led to experiments in America for using it in paper-making. This paper contains about one-third of its weight of asbestos. The paper burns with a flame, and leaves a white residue, which keeps the shape of the sheet if carefully handled. Any writing in common ink is perceptible, even after the organic substance of the paper is consumed.

The ancients employed the asbestos fibres for the manufacture of incombustible woven fabrics, which they chiefly used to wrap up the corpses previous to burning them, so as to keep all the ashes together, which were then placed in an urn, and this in the burial vault. In this way they hastened the decomposition of the bodies into ashes, which in our present method of burial is the result of many years' continued chemical decomposition. Most kinds of asbestos cannot be spun or woven without intermixture of cotton or linen fibre, as the asbestos fibres are not quite long enough. The intermixture of longer fibre makes the operation quite easy, and when the fabric is entirely ready it is simply placed in the fire, when the combustible linen or cotton is burned out and the incombustible texture remains.

Asbestos is an excellent material for the chemist as a filter. Being a silicate, it will filter acids which would destroy the ordinary filters. It is also used to dry air by placing the asbestos loose in a tube like a sponge, moistening it with sulphuric acid, and passing the air through in a gentle current.

The uses of asbestos have hitherto been too limited to make it of much importance as an article of commerce, but this mineral appears calculated to play a very important part in several branches of practical mechanics and industrial manufactures. Hence the new information recently acquired relative to the nature and extent of asbestos deposits, more especially in the northern portion of the American continent, becomes of interest. Although hitherto in modern times asbestos has had but a comparatively limited use, it has now been proposed to employ it for a variety of purposes—such, for example, as fire-resisting packing for the necks of revolving retorts, as a

material for packing piston-rods, pump-rods, and valve-spindle stuffing boxes, for making inconsumable paper, roofing, &c. Some of the ancient nations were well acquainted with certain of its remarkable properties, and are reported to have used it to a notable extent. What the earliest uses of asbestos may have been it is scarcely possible to be positive about at this remote age. The ancients were, however, acquainted with its fire-resisting properties, and spun it into yarn, which was woven into cloth. Accounts have come down to us of asbestos cloth having been used for napkins and articles of dress, which, when soiled, were cleansed by subjecting them to the action of fire. It was also employed as a wick for the lamps kept burning in ancient temples, and is, indeed, used for that purpose now by the Greenlanders. Besides being one of the most refractory substances, asbestos is, probably, one of the most perfect non-conductors and insulating mediums known; like all non-conductors, if cold, it takes protracted exposure to heat to change its temperature, but once hot, it in like manner tenaciously retains heat. This fact prevents its being used successfully for fire-proof safes. When the metal and fire are together, as in the cupola, or blast-furnace, it would appear to constitute a most enduring and heat-confining lining, particularly adapted for use where the metals or ores contain sulphides, as sulphides have no effect on asbestos, neither has any acid or combination of acids at present known. That the better qualities can be spun and woven is a well-known fact, as that has been accomplished in recent as well as ancient times, and cloth, closely resembling linen, produced, fully equal in strength and regularity of texture. A limited liability company for the manufacture of asbestos has been in operation for some time at Glasgow.

The article produced is not cloth or paper, but steam-packing. In this particular branch of manufacture, more than any other, is a thorough knowledge of asbestos necessary; for so terribly destructive are the influences to which steam-packing is exposed, that out of samples from more than one hundred mines in the United States, Scotland, Ireland, the Shetland Islands, Wales, Savoy, Piedmont, Germany, Austria, and Corsica, only two have been found which answered the purpose at all, and one of these but

indifferently. The complex requisites in asbestos to make satisfactory packing are so numerous and peculiar that it would be tiresome to enumerate them. The manufacture of asbestos steam-packing is a simple and beautiful process. The raw material is brought to the manufactory in considerable quantities from different parts of the world. It comes in sacks, and looks like chips and blocks of wood, but of a beautiful white colour. Experiments and study have demonstrated to the proprietors the best method of disintegrating and picking apart these chips and blocks, and reducing them to a fibrous condition like flax, jute, or cotton. The material once properly opened up, it is, by means of simple and ingenious machinery, formed into packing of the usual market sizes. These machines are as easily attended as weaving-looms, and each is under the care of a young woman, who, after a short time, becomes expert in the business, and is capable of turning out a first-class article. It is compactly reeled up in coils as made, and, when of proper size, is securely tied, covered with bagging, and sent to all parts of the world. Although the business has been in operation little more than two years the consumers of asbestos packing express themselves in the warmest manner as to its desirable properties and durability. In fact, the first packing in an ocean-going steamer was put in about sixteen months ago, and is still apparently as perfect as ever. The vessel alluded to is the 'Anglia,' one of the Anchor Line Transatlantic passenger steamers. She has made fourteen round trips to America and back, having steamed on the same packing over 98,000 miles. The case is similar with the first locomotive engine to which it was applied in Great Britain. The original packing, put in on 28th of July, 1871, remained in eleven months and twelve days, when the engine went into the repair-shop for overhauling, and the packing was taken out, and was apparently as fresh and useful as when first put in. The engine was an express passenger locomotive on the Caledonian Railway, and ran over 15,000 miles on the same packing. A professional journal, writing on this subject, well observes: "Few engineers who have to do with the steam engine are ignorant of the trouble which is met with in obtaining a really good piston-rod packing. Sound hemp, properly

'laid up' and copiously lubricated, makes a tight joint enough for a time, especially if the rod is in first-rate condition; but the period of tightness is usually short, and the gland requires constant screwing up, and much friction results, which is very prejudicial in small engines. If hemp is bad in the case of low-pressure engines, it is infinitely worse when we have to do with high steam, especially if the steam is slightly superheated. A process of slow carbonisation appears to go on, the hemp packing loses its elasticity, and becomes nearly useless for its intended purpose. All manner of schemes have been tried to get over the difficulty; combinations of cotton, india rubber, and wire gauze, such, for example, as Crickmer's patent packing, have hitherto given on the whole the best results. One inventor, indeed, dispenses altogether with cotton and rubber, and uses copper-wire gauze alone. In this case, the tightness of the joint is no doubt secured by the presence of water and oil lodged in the meshes of the gauze; and we have received very favourable reports from those who have tried this packing. It is still certain that something better than anything hitherto in use is required, and we have a strong belief that this something is supplied by asbestos."

Asbestos is found under various forms, from that of soft silky fibres to that of a hard block capable of taking a polish. As a rule, the lumps or blocks taken from the vein are easily broken up and separated into fibres extremely flexible, elastic in the sense that each fibre admits of great extension in the direction of its length without contracting again, greasy to the touch, and very strong. The fibres vary in length from a couple of inches to about two feet. They can easily be spun or woven if proper precautions are used. Furthermore, asbestos is an admirable nonconductor of caloric, and is practically indestructible by heat. All these conditions are just those which are required in a material for piston-rod packing; and it is therefore somewhat strange that, until a very recent period, no one thought of utilising asbestos for this purpose. The credit of suggesting it as a piston-rod packing is due to Mr. St. John Vincent Day, C.E., who read a very interesting paper on "Asbestos, with special reference to its use as steam-engine packing," before the Institution of

Engineers and Shipbuilders in Scotland. In referring to the value of the new packing, Mr. Day said: "The packing used for piston and valve rods or spindles has, as we all know, three prime elements of destruction to contend with, namely, an elevated temperature, friction, and moisture; and one of them only, namely, friction, has any appreciable effect on asbestos packing when the mineral is pure and properly prepared. No matter how high the temperature of the steam, how rapid the stroke of the piston, or how great the pressure of the steam, the packing seems to be unaffected by those conditions. In America, where the new packing was first used, some of it was taken from the piston-rod stuffing box of a locomotive engine, after having been in, and the engine at constant work, for three months, with steam at 130-lb. pressure per square inch, and making an average daily run of 100 miles, including Sundays; and, as you can see by the sample shown, the fibre, with the exception of being discoloured by oil and iron, is just as flexible and tenacious as originally. After having been once disintegrated, it appears impossible to so pack or mat the fibres together that they are not easily separable by the fingers."

In the course of the discussion, Mr. B. Connor, locomotive superintendent of the Caledonian Railway, stated that: "The advantage of the asbestos packing over the soapstone packing was that, with the latter, at the high temperatures of steam from 125 lbs. to 130 lbs., the lower portion of the packing got thoroughly charred, and another ring had to be put in after the first week; so that in the course of a month the packing had almost entirely changed. The asbestos packing, being practically incombustible, did not waste; and I suggest that the covering of the packing should be made of incombustible material also. At first I had applied it coiled round the piston-rod continuously; but I think it should be applied in rings. The inside of the packing seemed to me as fresh as when first put in. I believe it takes less oil to lubricate the piston-rod, for the oil remained on the rod, not being absorbed by the packing. It kept the rod beautifully polished, more so than any other packing."

This mineral appears calculated to supply a way out of one of the most troublesome obstacles to the use of

very high-pressure steam. There is, furthermore, not the slightest chance of the supply being exhausted; on the contrary, it is likely to last as long as our coal fields.

The practical utility of this substance, which is found in great abundance in the vicinity of New York, particularly on Staten Island, renders it worthy of more attention than it has hitherto had, on account of its value to firemen as a protection against frost as well as fire. The cloth made from this material enables the firemen of Paris to walk in flames for several minutes without injury, and its non-conducting power is equally a protection from the action of frost. Hats and coats may be made of it. With gloves of asbestos the fireman handles a firebrand or frozen hose without burning or freezing his fingers.

Moreover, the hose may be protected from the action of frost by jacketing the couplings with asbestos cloth, or what would be still more effectual, the hose itself may be made of this material instead of leather. In the Highlands of Scotland, this cloth is called mountain leather, from its toughness and flexibility.

In Siberia, they in some places manufacture purses, gloves, &c., of this substance. The Italians have manufactured cloth, pasteboard, and even a sort of lace from it. According to Sage, in China they manufacture sheets of paper six mètres long, and entire webs of cloth of it. A very valuable variety is found in Italy, the threads of which are of a shining whiteness, and have the peculiarity of seeming to be wound up in the mineral mass they form as the silk in the cocoon from which it is drawn. If one of the ends of these mineral fibres is seized it can be drawn out to a length eight or ten times the size of the piece from which it comes. The cloth made from it, however, presents little solidity. It is stated that an entire work was once printed on paper made from asbestos, and presented to the Institute of France by Madame Perpente.

The finer qualities of asbestos have been formed into gloves, neckties, &c., which can easily be cleaned by putting them in the fire.

The practical uses to which it is not only possible but probable that asbestos will be put, are almost numberless. Occupying as it does the position of a connecting link between the animal, vegetable, and mineral kingdoms, and

possessing the properties of all, scarcely too much can be claimed for it in regard to its adaptation to useful appliances. Asbestos boats, tubs, boxes, waggon bodies, and even railway carriages, which will neither rot, burn, nor splinter, are perfectly practicable and possible. In fact, so varied and peculiar are the qualities of asbestos, and so adaptable is it to the wants of mankind, that it may be looked upon as the "coming material."

Of course the utility of amianthus for any staple use must, like that of every other material, depend mainly upon its freedom from impurities; and this leads directly to the need of purifying processes, a matter to which comparatively little notice has been given. The latest and apparently the most feasible plan embraces the treatment of the substance with fluorine or hydrofluoric acid gas, to dissolve and eliminate the silex and other foreign components of the crude mineral, and thus secure a pure and fibrous condition of the asbestos. Thus freed from grit, it is proposed to reduce it to a flock, and then compress the same into a rope of octagonal, square, or flat form, and with a dense and adhesive structure, either with or without strengthening cords imbedded in the surface, or, as the equivalent of such cords, a covering of canvas or muslin. As proof against heat and acids, the purified material is asserted to possess great merit for packing the journal-boxes and other parts of machines exposed to excessive friction. How far the claims urged *à priori* in favour of this curious mineral—so long known to have the most useful properties, but only at the present time beginning to find some prospect of extended application—are likely to be sustained, can only be told by practice; but there is no doubt that it affords a promising field for investigation with a view to its use in many widely different industrial arts.

This remark will also apply to another mineral—mica—that now meets with but slender employment as a material for stove-windows, covers for gas globes, and a few other even more limited purposes. It occurs in considerable quantities in various portions of the Southern States, and parties apparently familiar with the subject state that, if a demand were once created sufficient to justify its systematic production, it could be laid down in the New York

market at one-fourth of the prices that it now, as a special and little-called-for article, commands.

Powdered steatite is used to produce the peculiar satin gloss on paper-hangings. Bisulphuret of tin is dusted over so as to adhere to the pattern. In what are called flock or velvet papers, dyed wools are minced into powder and similarly applied.

I have now enumerated and described a large number of raw materials and processes for the utilisation of various animal, vegetable, and mineral substances, and bring my labours to a close—not because the subject is exhausted, since every day furnishes new instances of what has become one of the most striking features of modern industry—to let nothing be lost, and to re-work with profit and advantage the residues of former manufactures—but for fear I should weary the reader with too ponderous a volume.

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WICKER-WORK.

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